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de l'énergie atomique

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INFO-0347

DETERMINATION OF RADON FLUX RATES
IN A URANIUM MINE
(CLUFF LAKE, SASKATCHEWAN)

by

SENES Consultants Limited

A research report prepared for the
Atomic Energy Control Board
Ottawa, Canada

Project No. 4.105.1

December 1989

EXECUTIVE SUMMARY

The Atomic Energy Control Board contracted SENES Consultants Limited to design and implement a field program at Amok Limited's Cluff Lake uranium mine, with the overall objective of obtaining reliable radon flux data applicable for use in the VENTRAD computer model. The VENTRAD model was developed to model underground mine ventilation systems.

To avoid the uncertainties inherent in localized flux measurements made on small surfaces, radon flux measurements were determined through measurement of incremental changes in the concentration of radon between the incoming and outgoing air in selected areas of the underground workings.

The locations were selected throughout the mine in both ore and sterile rock. Average radon flux rates measured during three field campaigns were as follows:

- Sterile Rock Decline	4 pCi/m ² .second
- Sterile Rock Mainway	25 pCi/m ² .second
- Worked-out Stope	100 pCi/m ² .second
- Active Work Stope	240 pCi/m ² .second
- Work Face	14,000 pCi/m ² .second

Data collected during the three field programs were used to validate the VENTRAD computer model. The results of the validation exercise suggest close agreement between predicted and measured air flow rates and radon concentrations in "steady state" areas of the mine. Air flow rates and radon concentrations were overestimated for areas immediately impacted by auxiliary ventilation fans and ore transfer mill holes which connect the ore extraction and haulage levels of the mine.

Résumé

La Commission de Contrôle de l'Énergie Atomique a passé un contrat avec SENES Consultants Limited pour concevoir et exécuter des campagnes de mesure destinées à mesurer les flux de radon dans la mine souterraine de Amok Limited à Cluff Lake. Les flux mesurés sont utilisés dans le modèle VENTRAD. Le modèle VENTRAD a été développé pour modéliser les réseaux d'aérage des mines souterraines.

Afin d'éviter les incertitudes inhérentes aux mesures localisées à de petites surfaces, les flux de radon ont été déterminés à partir de l'accroissement de la concentration de radon dans l'air entrant et sortant de régions sélectionnées de la mine.

Les régions étudiées ont été sélectionnées pour représenter l'ensemble de la mine et comprennent des zones minéralisées et des zones stériles. Les flux de radon moyens mesurés au cours de trois campagnes sont les suivants:

- descenderie au stérile	4 pCi/m ² s
- galerie d'accès principale au stérile	25 pCi/m ² s
- chantier épuisé	100 pCi/m ² s
- chantier en production	240 pCi/m ² s
- front	14,000 pCi/m ²

Les résultats collectés au cours des trois campagnes ont été utilisés pour caler le modèle VENTRAD. Les résultats de cet exercice suggèrent un bon accord entre les débits d'air calculés et mesurés et les concentrations de radon dans les régions de la mine en régime stable. Les débits d'air et les concentrations de radon sont surestimés dans les zones directement affectées par une ventilation secondaire et par les chutes reliant le niveaux d'extraction aux niveaux de roulage.

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1.0 INTRODUCTION

1.1 General

In 1986 the Atomic Energy Control Board (AECB) completed a research project in which a computer model (VENTRAD) was developed to model underground mine ventilation systems. Such predictions are particularly important in uranium mines where the exposure of workers to radon and its daughters is a prime concern. The accuracy of the radon/radon daughter concentration predictions by the computer model depends to a large extent on the input parameters describing the radon source term (i.e. the number, location and type of sources and their unit flux rates). At present, there is a lack of reliable data pertaining to radon sources in general and to these parameters, in particular in uranium mines.

To help fill this data gap, the AECB contracted SENES Consultants Limited to design and implement a field program at Amok Limited's Cluff Lake mine. This report outlines the results of this study.

1.2 Study Objectives

The objectives of the study as set out in request for proposal were as follows:

- . to determine the flux of radon emitted per unit surface area in selected locations of the underground uranium mine;
- . to measure carefully parameters that can have an influence on radon flux;
- . to test the VENTRAD computer program using the input parameters measured in the mine, and;
- . to determine the total flux of radon per unit surface area from the total amount of radon exhausted from the mine and the total surface area of the mine openings.

1.3 Assistance From Amok Limited

The co-operation of Amok Limited and the Cluff Lake mine personnel was essential for this project to be carried out. In the initial work plan it was proposed that the assistance provided by Amok would include the part time services of one of their radiation technicians to carry out the routine radon sampling. Unfortunately operational priorities at the mine and mill facilities did not allow sufficient available time for this routine sampling to be carried out. Amok did provide transportation for SENES personnel from Saskatoon to the mine and accommodations at the Cluff Lake facility. On-site Amok staff provided valuable assistance to the SENES field team during their three sampling campaigns. The assistance provided by Amok Limited is gratefully acknowledged.

1.4 Report Outline

The remainder of this report is organized into the following chapters:

Chapter 2, Mine Description, provides a brief overview of the Cluff Lake site and the underground mining operation.

Chapter 3, Field Visits, describes the three field campaigns carried out by SENES personnel and provides a brief summary of the gathered data. The configuration of mine during each field visit is also described in this chapter.

Chapter 4, Interpretation of Data, presents an in-depth review of the data gathered during the three field campaigns and an interpretation of the data with respect to radon exhalation.

Chapter 5, VENTRAD Model Implementation and Validation, provides a brief description of the VENTRAD computer model and the implementation of this model for the Cluff Lake underground mine. Through this application the validity of the model was subsequently assessed.

Chapter 6, Conclusions and Recommendations, presents a summary of the conclusions and recommendations stemming from this study.

2.0 MINE DESCRIPTION

2.1 Cluff Lake Site

The Cluff Lake uranium mine is located 720 kilometres northwest of Saskatoon, Saskatchewan (see Figure 2.1). The mining and milling facilities are operated by Amok Ltd. on behalf of the owners Amok Ltd. (80%) and the Saskatchewan Mining Development Corporation (20%). The Saskatchewan Mining Development Corporation is now part of CAMECO, the Canadian Mining and Energy Company.

The uranium deposits are found in a number of small zones rather than one large orebody and as a result the mining methods used at Cluff Lake include a combination of open pit and underground mining. Mining at Cluff Lake began in 1980 with open pit mining in the high grade D Zone. In 1986 underground mining began at Dominique-Peter (D-P) which was sampled as part of this study. As of the fall of 1988 Cluff Lake had proven reserves sufficient for at least ten more years of operations (Meadley et al., 1988).

2.2 Ore Grade and Formation

The uranium deposits at Cluff Lake are vein type deposits of high grade ore. The first orebody mined and milled, the "D" orebody, averaged 6% uranium (as U_3O_8), with certain sections of the orebody grading in excess of 40% uranium. The ore from the D-P mine is lower grade material and on average produces typical mill feed grade of 0.45% uranium. Some sections of the mine have produced material as high as 6% uranium, but on average the ore is typically in the range of 0.3% to 0.8% uranium. Current ore production averages 200 tonnes per day. Mining is performed March through November with mining operations suspended during the winter months.

2.3 Mining Technique

At Dominique-Peter underground mining is carried out using the "under cut and fill" method. The D-P mine has two levels, the 220 Level (220 metres above sea level) and the 170 Level, which are accessed by a decline ramp from the surface. All personnel, vehicles, ore and waste rock access the 220 and 170 Levels via the Decline.

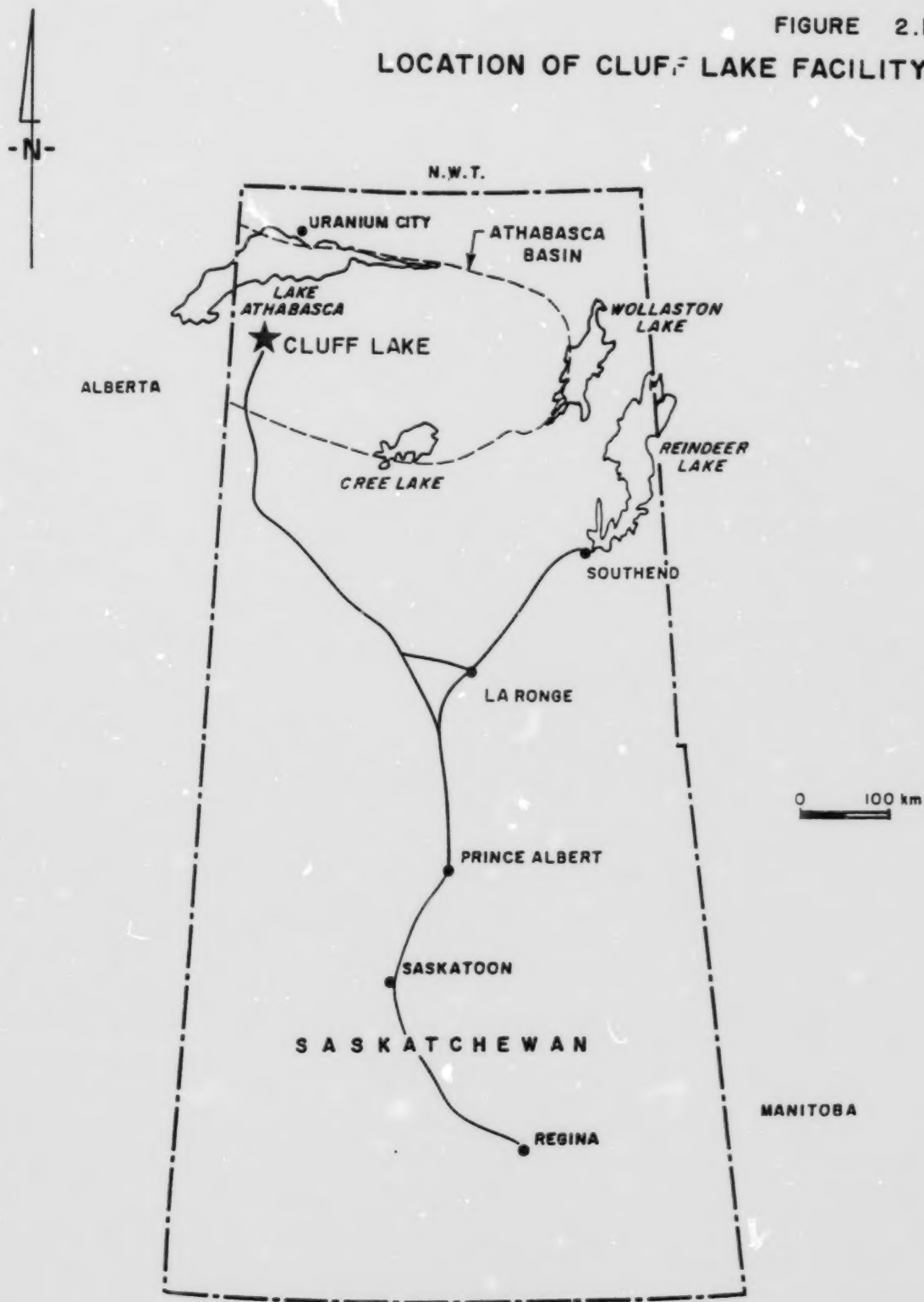
The 220 Level provides access to the uranium ore veins and is comprised of several large mainways cut through sterile rock. The three deposits accessed by the 220 Level (referred to as A, B and C zones) run in a north to south direction. Figures 2.2 and 2.3 depict the 220 and 170 Levels as of August 1987, respectively. Typically several mining faces are in operation at any one time. Uranium ore and waste rock from these faces are mucked out after blasting and dumped down 1 metre diameter mill holes connecting the 220 mining Level to the 170 haulage Level.

For the most part a two man crew, consisting of a driller and a driller's assistant, works each mining face. The width of the open face depends on the size of the vein and can range in width from approximately 1 metre (as in Photo 2.1) to several metres.

Blasting can occur at any time throughout the shift. Each blast is confined to the work face and generally only requires that the miners involved in the blast retreat to a safe area until the fumes have cleared (ten to twenty minutes). Because of the small size and localized nature of the explosion there is no requirement to evacuate the entire mine before each blast takes place.

A combination of electrical and diesel powered equipment is used underground (see Photos 2.2 and 2.3).

FIGURE 2.1
LOCATION OF CLUFF LAKE FACILITY



PHOTOGRAPH 2.1



Narrow Ore Deposit
(Ore seam highlighted by red lines)

PHOTOGRAPH 2.2



Electric Powered Scoop

PHOTOGRAPH 2.3



Diesel Powered Hauler



FIGURE 2.2
220 LEVEL CONFIGURATION
AUGUST, 1987

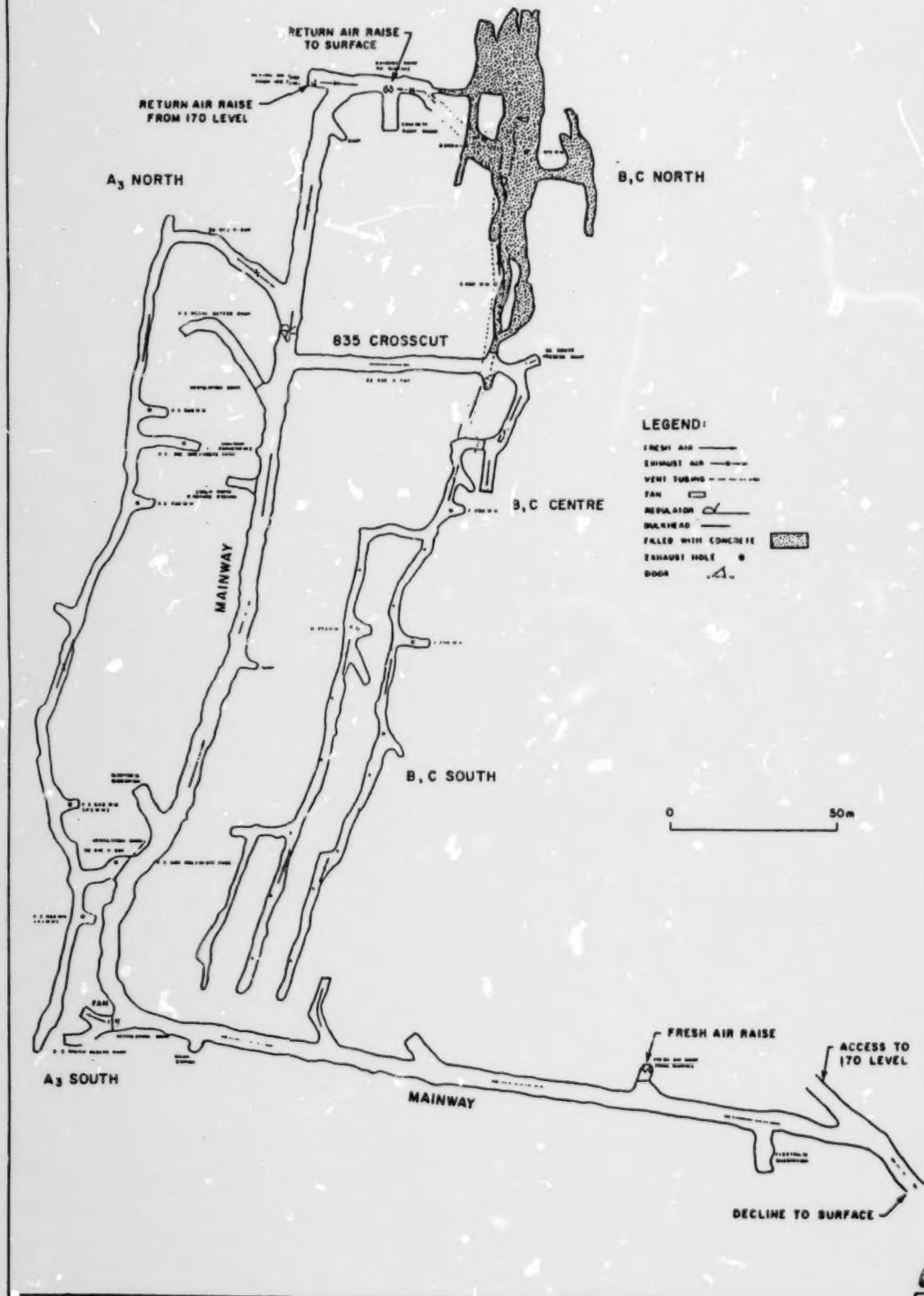
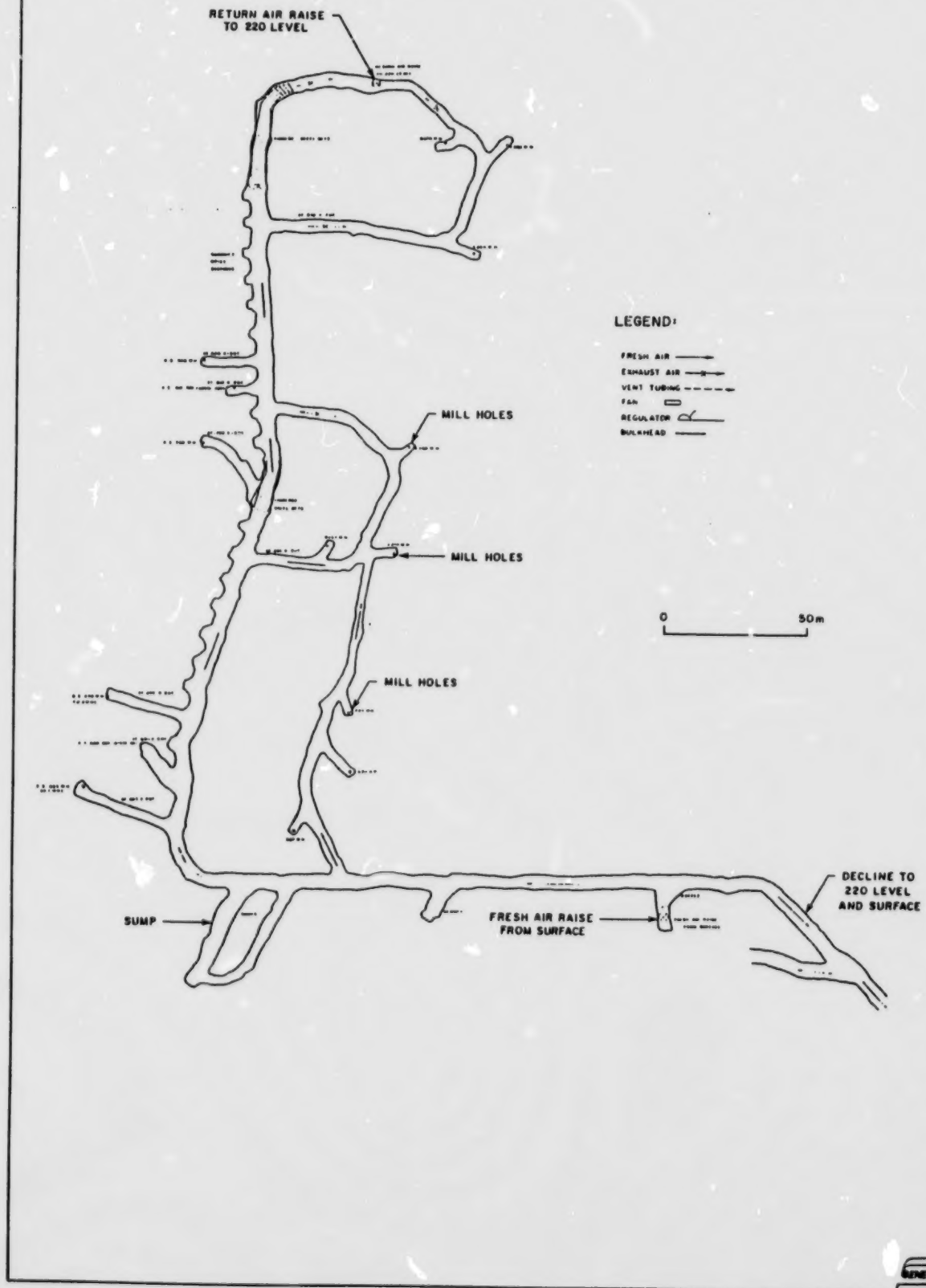


FIGURE 2.3
170 LEVEL CONFIGURATION
AUGUST, 1987



The 170 Level provides access to the base of the mill holes where the ore and waste rock are loaded into haulers for transport up the Decline to the surface facilities. The main minewater collection sump is also located on the 170 Level.

In comparison with many other mines the D-P mine is relatively dry. No large volumes of naturally occurring groundwater were observed entering the mine during any of the three field campaigns. Water is, however, used extensively throughout the mine as a coolant and dust suppressant during drilling operations. As a result, pools of water are encountered in the vicinity of drilling and mucking activities. Small sumps are scattered throughout the mine to collect this water and direct it to the main minewater sump on the 170 Level, from which it is pumped by pipeline to the mill facility for uranium recovery and subsequent treatment.

Photos 2.4 to 2.6 depict several of the underground operations. These photos also show the rough textured conditions of the wall surfaces, the nature of the roof support used in the mine (wire mesh and rock bolts) and the various sizes of stopes encountered underground.

2.4 Ventilation System

Fresh air is circulated throughout the mine to flush out blasting and diesel fumes, dust and radon/radon daughter products.

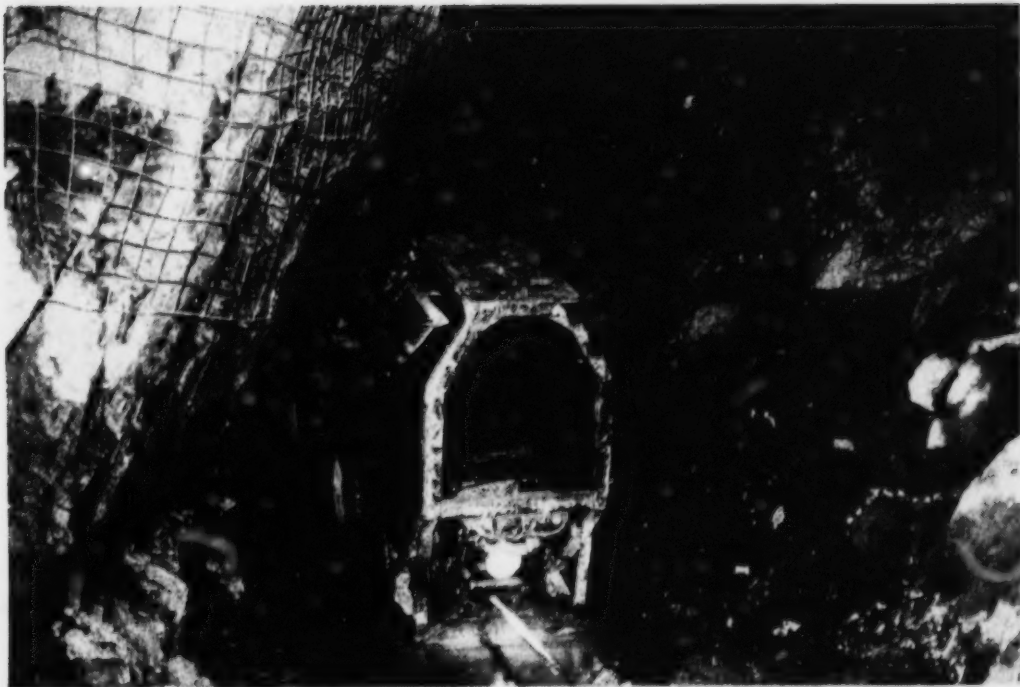
The mine is positively pressurized by a large fan on surface which forces fresh air into the mine at both the 220 and 170 Levels via the fresh air raise (FAR). For the 220 Level, the FAR is located near the intersection of the Decline and the 220 Level Mainway (see Figure 2.2) while for the 170 Level the FAR is located near the base of the Decline (see Figure 2.3). Exhaust

PHOTOGRAPH 2.4



Small Scoop Dumping Ore
Into Mill Hole

PHOTOGRAPH 2.5



Small Scoop Mucking Out Ore

PHOTOGRAPH 2.6



Mill Hole at 170 Level

air from the 220 Level is returned to the surface via the main return air raise (RAR) located at the north end of the 220 Level (see Figure 2.2). A separate return air raise located in close proximity to the RAR allows the exhaust air from the 170 Level to reach the 220 Level and subsequently the RAR. A portion of the fresh air supplied to the 170 Level is allowed to exhaust up the Decline to the surface. This flow provides the fresh air supply for the operators of the haulage vehicles travelling on the Decline. The flow up the Decline is controlled by double set of ventilation doors located approximately half way up the Decline.

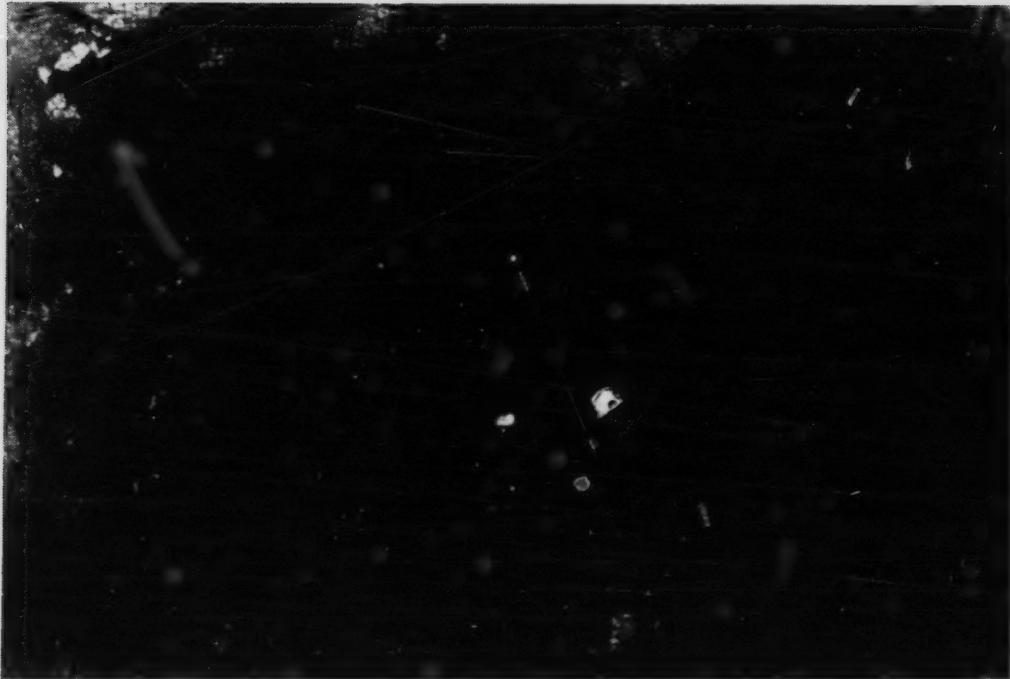
Ventilation surveys of the entire mine are conducted on a monthly basis by radiation protection staff. Air flow rates are measured at a series of specific locations in the mine to determine the distribution of air flows throughout the underground workings. These measurements provide the data necessary in the verification that a balanced air flow condition exists underground (quantity of air in equals quantity of air out). Figure 2.4 illustrates the balanced air flow for September 1987. Photo 2.7 depicts the ventilation survey technique, whereby the cross-sectional area of a stope or mainway is divided into equal sized areas and air flow measurements are taken in the centroid of each area.

Throughout the underground workings, auxiliary fans and ducting are used to transfer the fresh air from the mainways to the various work faces. Fans range in size from as small as 3 horsepower (providing air flows of 6,000 to 10,000 cfm) to as large as 50 horsepower (providing air flows of 30,000 cfm).

Photo 2.8 depicts a typical auxiliary ventilation fan and ducting installation.

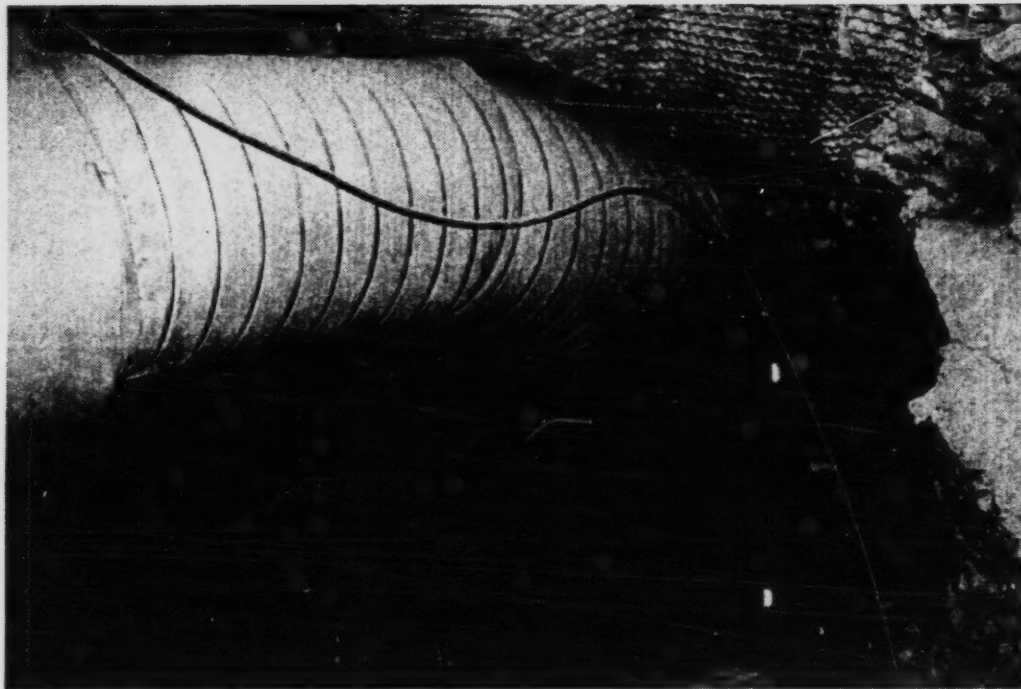
To control the airflow throughout the mine, a series of ventilation doors were installed at selected locations. These

PHOTOGRAPH 2.7



Ventilation Survey

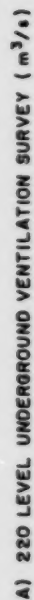
PHOTOGRAPH 2.8



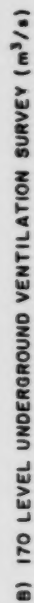
Auxiliary Ventilation Ducting Suspended
From Ceiling



W



NY: N. River i r. Guld

$$(1) \frac{1}{3} = \frac{2118}{6354}$$


Mr. M. Becker, 12. Grad

$$(1.5)^3 = 211.9 \text{ cm}^3$$

doors can block/or direct the air flow to an area or can be equipped with fans to allow a specific quantity of fresh air into a particular area. The ventilation door at the A-3 south access ramp is an example of the latter situation, where approximately $12.5 \text{ m}^3/\text{s}$ of the $46.5 \text{ m}^3/\text{s}$ of fresh air available in the 220 Mainway is introduced into the A-3 south sill area using a ventilation door and fan installation (see Photo 2.9, an example of vent door/fan in Mainway near 835 Crosscut).

PHOTOGRAPH 2.9



Ventilation/Fan Doorway on 220 Mainway



3.0 FIELD VISITS

3.1 General

As stated in Section 1.3, it was the intent of the original project plan to have Cluff Lake Mine personnel carry out the routine underground radon sampling. Unfortunately, extenuating circumstances at the surface facilities did not allow Cluff personnel sufficient available time for any routine sampling to be carried out. As a result the data collected during three field visits by SENES personnel provide the data used in this study.

The three visits took place in August and October 1986 and October 1987. Sampling methodology and results of the three field visits are summarized in the following sections.

3.2 Sampling Equipment and Procedures

3.2.1 Radon Daughter Sampling

Radon daughter levels are measured at selected work stations in the mine on a regular basis (typically once a day) by Cluff Lake radiation protection personnel. Through these measurements the radiation protection staff monitor underground radon daughter levels and recommend appropriate ventilation system adjustments to ensure that workers' exposure to radon daughter levels during the course of their work underground is kept as low as reasonably achievable.

The measurement procedure is based on the Modified Rollé technique whereby a known volume of air is drawn through a 0.80 micron Type AA Millipore filter by a small personal air sampling

pump, and the alpha activity of the material collected on the filter is measured over a specific time interval using an EDA RD200 alpha counter. Specific details of the modified Rollé sampling technique are presented on Table 3.1.

3.2.2 Radon Sampling

Radon gas sampling and analysis are not carried out at the Cluff Lake facility as part of the radiation monitoring/protection program. Although some radon sampling was conducted during the early stages of the operation, it was discontinued in the early 1980's. As a result the only radon data available for use in this study are those collected by SENES personnel during the three field visits. This section describes the procedures used to collect and analyze radon samples during the field visits.

Radon gas concentrations were determined on a grab sample basis using Eberline SC-5 scintillation cells and SAC-R5 scintillation detectors. The SAC-R5 is a 5 inch (12.7 cm) diameter 10 stage, end window photomultiplier tube assembly mounted in a light tight enclosure designed for measuring radon gas collected in alpha scintillation cells. For this application it was coupled to a Eberline Model MS-3 Mini Scaler. Photo 3.1 shows the counter assembly. The SC-5's are 0.5 L cells used to collect gaseous samples for analysis of radon. The cells are made of transparent plastic and the inner walls are lined with silver-activated zinc sulfide scintillation material. Two valves are provided on top of each cell so that a flow through method can be used for collecting the air sample or purging the cell.

In this study, each air sample to be analyzed for radon was collected by the flow-through method using a small portable pump to draw filtered air through the cell. A filter was always in place at the inlet side of the scintillation cell to ensure that

Table 3.1

MODIFIED ROLLE METHOD AS
APPLIED AT CLUFF LAKE FACILITY

Sampling Sequence

Time Interval

Collection of Sample	0 - 5 minute
Growth of Sample	5 - 12 minute
Counting of Sample	12 - 15 minute

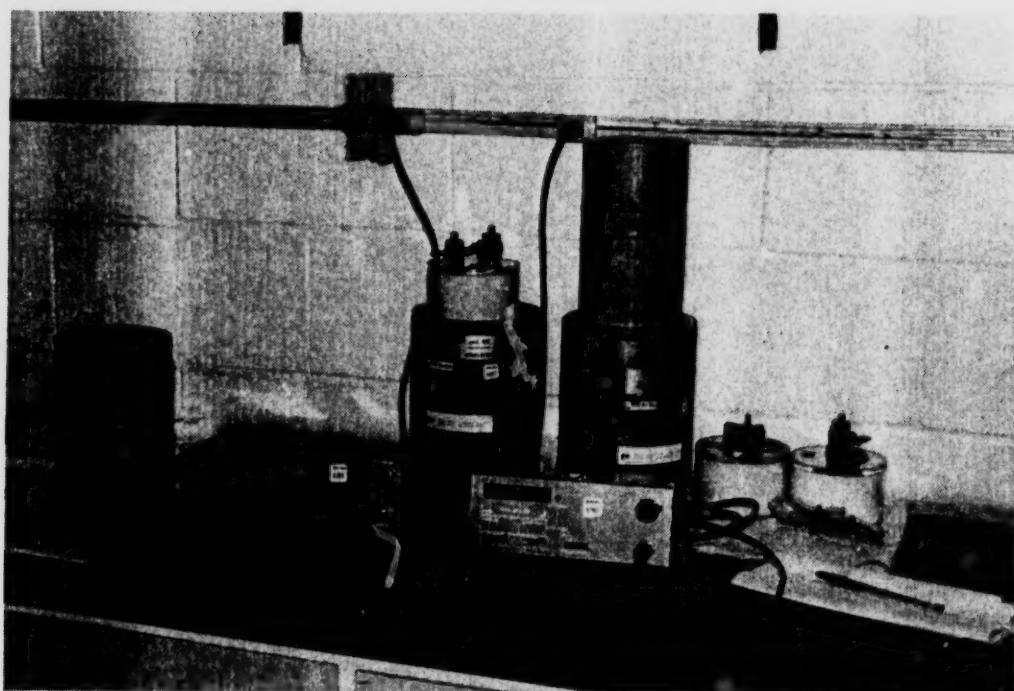
Sampling Details

Pump Flowrate	2.5 - 3.0 litres per minute
Filter Type	0.80 micron Type AA Millipore
Counter Type	EDA RD 200
Counter Efficiency	35 - 45 %
Counter Background	measured daily, generally 5 - 15 counts per minute

Formula For Calculation

$$\text{Working Level} = \frac{(\text{Total Counts} - \text{Counter Bkdg}) \times (0.000313)}{(\text{Flowrate}) \times (\text{Counter Efficiency})}$$

PHOTOGRAPH 3.1



Radon Counter Assembly

particulate matter and radon daughters were removed prior to the air entering the cell. To ensure that the original air in the cell was replaced with filtered air from the mine atmosphere, the portable pump was run for four to five minutes to allow at least ten air changes to take place within the cell. A schematic for this sampling set-up is presented on Figure 3.1. (See Photo 3.2)

The parameters noted at the time of sampling included: scintillation cell number, time of sample, sample location, and conditions at the time of sampling. Figure 3.2 presents a copy of the field sampling sheet.

To determine the concentration of radon in the air sample, the cells were placed inside the SAC-R5 chamber and the scintillations produced by the radon progeny were counted. A response factor of 2.3 counts per minute per picoCurie per litre was used for the SC-5, SAC-R5 and MS-3 counter assembly. The cells were generally counted for at least ten minutes.

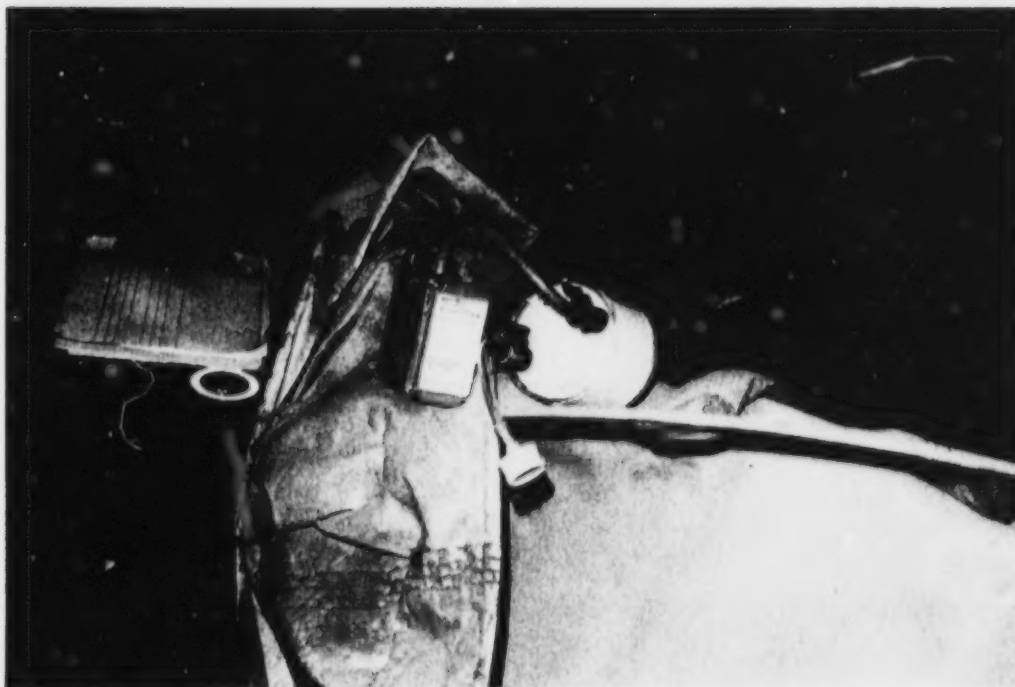
Cell Background

The cells were purged with (aged) nitrogen after each use to prevent a buildup of radon daughters inside the cell. Prior to each use the cell's background count was determined and recorded for future reference. Cells with background counts greater than 1.5 to 2 counts per minute were reflushed with nitrogen and left overnight before a second background count was attempted. When an acceptable background count was achieved the cell was made available for sampling.

Counter Background

Prior to each day's use the background count for each counter assembly was determined. This was accomplished by emptying the

PHOTOGRAPH 3.2



Radon Collection Assembly

FIGURE 3.1

RADON SAMPLING TRAIN CONFIGURATION
(FLOW THROUGH METHOD)

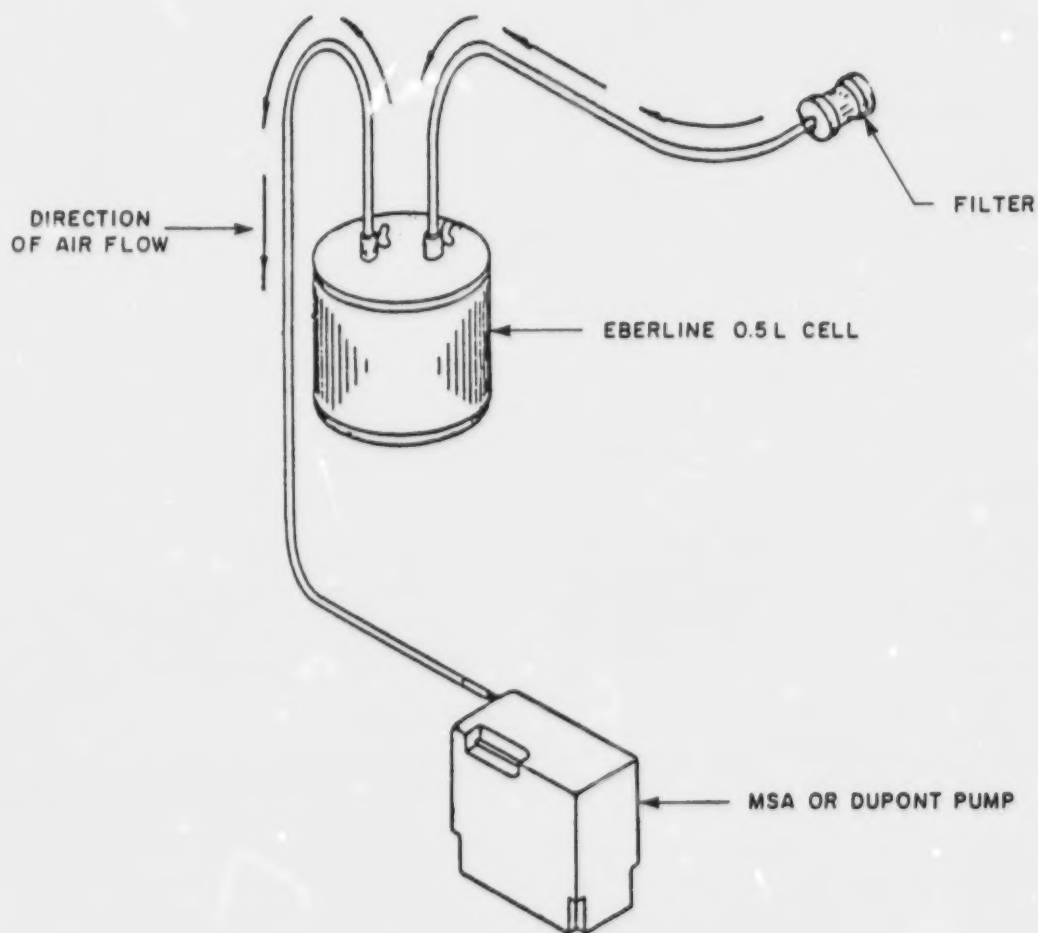


FIGURE 3.2
FIELD SAMPLING SHEET

FIELD SHEET FOR RADON FLUX MONITORING PROJECT AT CLUFF LAKE MINE
=====

DATE: _____		SAMPLED BY: _____					
LOCATION							
CELL#							
COUNTER							
TIME OF SAMPLE							
TIME OF COUNT							
NET HOURS							
TOTAL COUNTS							
COUNT TIME (min)							
GROSS CPM							
CELL BKGD (cpm)							
COUNTER BKGD(cpm)							
NET CPM							
TIME FACTOR							
CELL FACTOR	2.3	2.3	2.3	2.3	2.3	2.3	2.3
RADON CONC. (pCi/l)							
RADON DAUGHTER DATA							
PUMP FLOWRATE							
DAUGHTER COUNTS							
WORKING LEVELS							
EQUILIBRIUM							
SAMPLE SITE PARAMETERS/CONDITIONS AT TIME OF SAMPLING							
TEMPERATURE							
RELATIVE HUMIDITY							
VENTILATION RATE							
WATER							
MINING ACTIVITIES							
COMMENTS							

WATER:

A -dry C -minor flowing water E -pools of water
B -wet D -major flowing water

MINING ACTIVITIES:

A -crew setting up/msc work	D -drilling	H -haulage equipment
B -bolting	M -mucking	I -inactive
C -construction, service installation	S -slushing	F -finished



counter of any cells and conducting a twenty minute count. The daily background was recorded and incorporated into the following formula:

$$\text{Radon Concentration (in pCi/L)} = \frac{\left[\begin{array}{l} \text{Gross Counts - Cell Background - Counter Background} \\ \text{Per Minute} \qquad \qquad \text{in CPM} \qquad \qquad \text{in CPM} \end{array} \right]}{(2.3 \text{ CPM/pCi.L}^{-1}) \times (\text{Time Factor})}$$

where Time Factor accounts for the growth of radon progeny between the time of sample collection and the time of the count.

3.2.3 Uncertainties Associated with Measurements

Uncertainties associated with the measurements of radon and radon daughters in the mine can be either systematic or random. Systematic uncertainties arise from biases in the measurement program while random uncertainties arise from variability and imprecision. An example of the first type of uncertainty might be the situation where mill holes were consistently uncovered when thought to be covered (or vice versa) or measurements made when the actual airflow was consistently higher (or lower) than thought to be. Examples of the latter type of uncertainty would include the natural variability due to consistently changing mining conditions (e.g. rate, grade, area); changing radon influx (mine water, grade, pressure changes) and ventilation conditions (mill holes opening and closing, changing miners configurations and the like).

Due to the dynamic nature of the mining operation itself and natural variability in factors which have potential to affect workplace radon and radon daughter levels, it is difficult to qualitatively evaluate this uncertainty although a crude measure of this uncertainty is provided by the range of values measured

within the mine at one time (campaign) and by the range of values measured from one campaign to the next. Unfortunately, due to other priorities the routine day-to-day measurements which would have provided additional information with regard to the uncertainty in radon levels could not be made by the Cluff personnel.

Something can be said however with regard to the uncertainties arising from the actual measurement of radon and radon daughter levels itself. These include statistical counting errors, uncertainty (and cell to cell variability) about the cell calibration factor, uncertainty about air pump calibration, etc. In this regard Table 3.2 presents the relative uncertainty in radon and radon daughter levels attributable to counting statistics alone. Radon uncertainties are based on 10 minute counts with a nominal cell and counter backgrounds 1.5 and 0.3 cpm respectively. The working level uncertainties are based on the modified Rollé method, 2.5 litre per minute flow and 45% count efficiency.

These tables can be used when reviewing the data presented in subsequent sections to determine the uncertainty associated with concentrations presented. For example a radon concentration of 5 pCi/L has an uncertainty of ± 0.53 pCi/L (approximately 10%) attributable to counting.

3.3 August 1986 Field Campaign

3.3.1 Purpose and Duration

The first field visit to the mine took place from 4 to 8 August 1986. The purpose of the visit was to examine the underground mining operation, to discuss the project with the Cluff Lake radiation protection personnel and to collect sufficient information with which to develop a sampling program.

Table 3.2

RELATIVE UNCERTAINTY IN MEASUREMENT
OF RADON AND RADON DAUGHTER
ATTRIBUTABLE TO COUNTING STATISTICS

Radon Conc. <u>(pCi/L)</u>	Relative Uncertainty <u>(+ pCi/L)</u>	Radon Daughter <u>(WL)</u>	Relative Uncertainty <u>(+ WL)</u>
0.1	0.26	0.001	0.001
0.5	0.29	0.005	0.001
1	0.33	0.10	0.001
5	0.53		
10	0.71	0.050	0.002
50	1.5	0.100	0.003
100	2.1	0.500	0.007
500	4.7		

3.3.2 Mine Configuration

As stated in Section 1.2, one of the objectives of this study was to test the VENTRAD computer program using input parameters measured in the mine. To accomplish this objective a schematic of the mine layout was prepared depicting the branch network of stopes and Mainways on the 170 and 220 Levels. Locations of ventilation fans and the direction of air flow based on the most recent Cluff ventilation survey available at that time were also shown on these schematics (see Figures 3.3 and 3.4 for 220 Level and 170 Level configurations and Figures 3.5 and 3.6 for the branch networks).

3.3.3 Results

Three days of sampling yielded a total of forty four radon and thirty nine radon daughter samples. Measurements were made on the 220 Level, 170 Level and the Decline. Table 3.3 presents a summary of the results obtained during the August 1986 campaign, while Appendix Table A.1 presents the detailed calculations. The radon concentrations ranged from below 0.1 pCi/L at the fresh air raise 220 Level to as high as 8880 pCi/L at the 900 C mill hole (ventilation had been turned off). These two concentrations represent the two extremes, with radon concentrations on the 220 and 170 Levels in the mine typically within the range of 5 to 250 pCi/L.

The radon daughter levels ranged from less than 0.001 WL, on the Decline near the split between the 170 and 220 Levels, to a high of 4.1 WL at the 900 C mill hole. In accordance with the above noted radon concentrations, these two radon daughter levels represent the two extremes and working levels in the mine typically ranged from 0.01 to 0.20 WL.

TABLE 3.3 : RADON AND RADON DAUGHTER RESULTS FOR AUGUST 1986 CAMPAIGN
(CLUFF LAKE D-F MINE)

DATE	SITE #	LEVEL	SAMPLE LOCATION	RADON CONC (pCi/L)	RADON DTR'S (WL)	"E" RATIO
86-08-05	H1	220	A3 South Ramp	5.2	0.004	0.08
86-08-05	835	220	835 Crosscut (X-Cut)	46.4	0.047	0.10
86-08-05	H2	220	A3 North Return Air	48.3	0.114	0.24
86-08-05	CN	220	22-71 to 22-69 (C1 Sill)	171.5	0.156	0.09
86-08-05	BN	220	22-73 to 22-75 (B North, VS#9)	221.1	0.168	0.08
86-08-05	A1	220	2nd Electrical Substation	3.3	N/A	-
86-08-05	A1.5	220	Mainway Outside Lunchroom	5.1	N/A	-
86-08-05	LUN	220	Inside Lunchroom	4.2	N/A	-
86-08-05	20.5	170	Mainway Downstream Of Sump	3.4	N/A	-
96-08-05	20	170	Above 170 Sump	4.1	N/A	-
86-08-06	21	260	Decline Ramuck #1 (Near Top)	3.8	0.008	0.21
86-08-06	21.5	260	Decline Between Vent Doors	1.5	0.002	0.13
86-08-06	22	220	Decline At 170/220 Split	0.3	<.001	-
86-08-06	22.5	220	Mainway By FAR (Vent Stat.#2)	0.1	<.001	-
86-08-06	A1	220	Mainway By Sump and A3 Access	3.5	0.003	0.09
86-08-06	A1.5	220	Mainway Outside Lunchroom	4.8	0.007	0.15
86-08-06	835	220	835 X-Cut (Vent Stat.#5)	104.4	0.080	0.08
86-08-06	835	220	835 X-Cut At B,C Split (VS#6)	59.9	0.050	0.08
86-08-06	CS	220	C -South End (Vent Stat.#15)	58.7	0.026	0.04
86-08-06	BS	220	B -South End (Vent Stat.#16)	42.3	0.020	0.05
86-08-06	3	220	Mainway Upstream of 170 Exhaust	96.0	0.088	0.09
86-08-06	4	220	170 Return Air Raise At 220 Level	21.3	0.048	0.23
86-08-06	5	220	Mainway Before RAR To Surface	98.6	0.061	0.06
86-08-06	6	220	BC Sill Return Air At RAR, (VS#10)	58.5	0.040	0.07
86-08-06	BN	220	22-73 to 22-75 (B North, VS#9)	236.9	0.132	0.06
86-08-06	CN	220	22-71 to 22-69 (C North, VS#8)	144.6	0.123	0.09
86-08-06	H2	220	A3 North (VS#13)	66.8	0.168	0.25
86-08-07	A1	220	Mainway Before Sump, Near A3	1.3	0.001	0.08
86-08-07	A1	220	Mainway After Sump, Near A3	1.6	0.001	0.06
86-08-07	H2	220	A3 North Return Air	22.9	0.079	0.35
86-08-07	835	220	835 Crosscut At 8-1	205.6	0.153	0.07
86-08-07	835	220	835 Crosscut At 8-3	174.6	0.172	0.10
86-08-07	835	220	835 Crosscut At 8-5	242.1	0.172	0.07
86-08-07	835	220	835 Crosscut At 8-7	212.8	0.230	0.11
86-08-07	835	220	835 Crosscut At 8-9	267.7	0.170	0.06
86-08-07	835	220	835 Crosscut At 8-11	177.1	0.254	0.14
86-08-07	835	220	835 Crosscut At 8-13	115.9	0.166	0.14
86-08-07	4	220	170 Return Air Raise At 220 Level	44.8	0.067	0.15
86-08-07	900	220	900 C Mill Hole (22-08)	8879.6	4.138	0.05
86-08-07	20.5	170	Decline Upstream of Sump (VS#2)	1.1	0.010	0.93
86-08-07	746	170	17-59 to 17-56 (746 X-Cut)	10.9	0.013	0.12
86-08-07	746	170	17-59 to 17-62 (746 X-Cut)	14.4	0.012	0.08
86-08-07	900	170	900 C Mill Hole (17-08)	20.0	0.018	0.09
86-08-07	900	220	900 C Mill Hole (22-08)	355.2	0.387	0.11

NOTE: See Table 3.2 for uncertainty associated with radon and radon daughter concentrations attributable to counting statistics.

FIGURE 3.3
MINE CONFIGURATION FOR 220 LEVEL
AUGUST, 1986

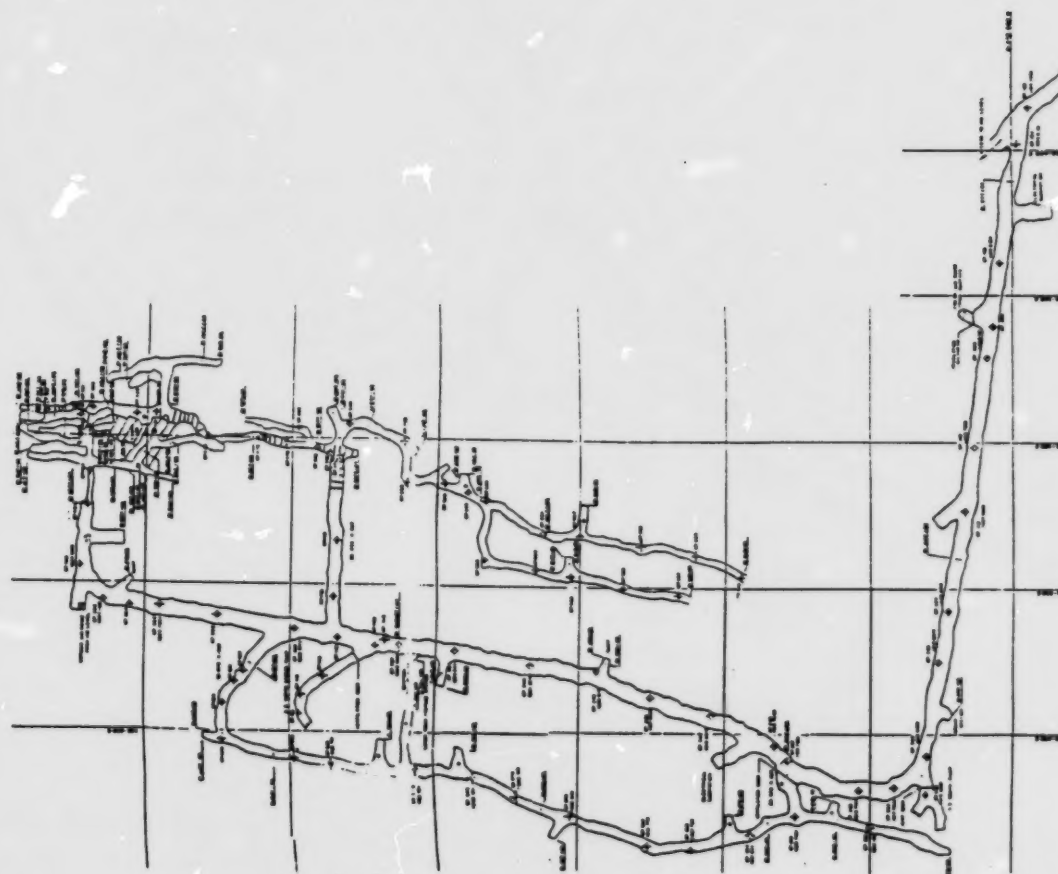


FIGURE 3.5
BRANCH NETWORKS FOR 220 LEVEL

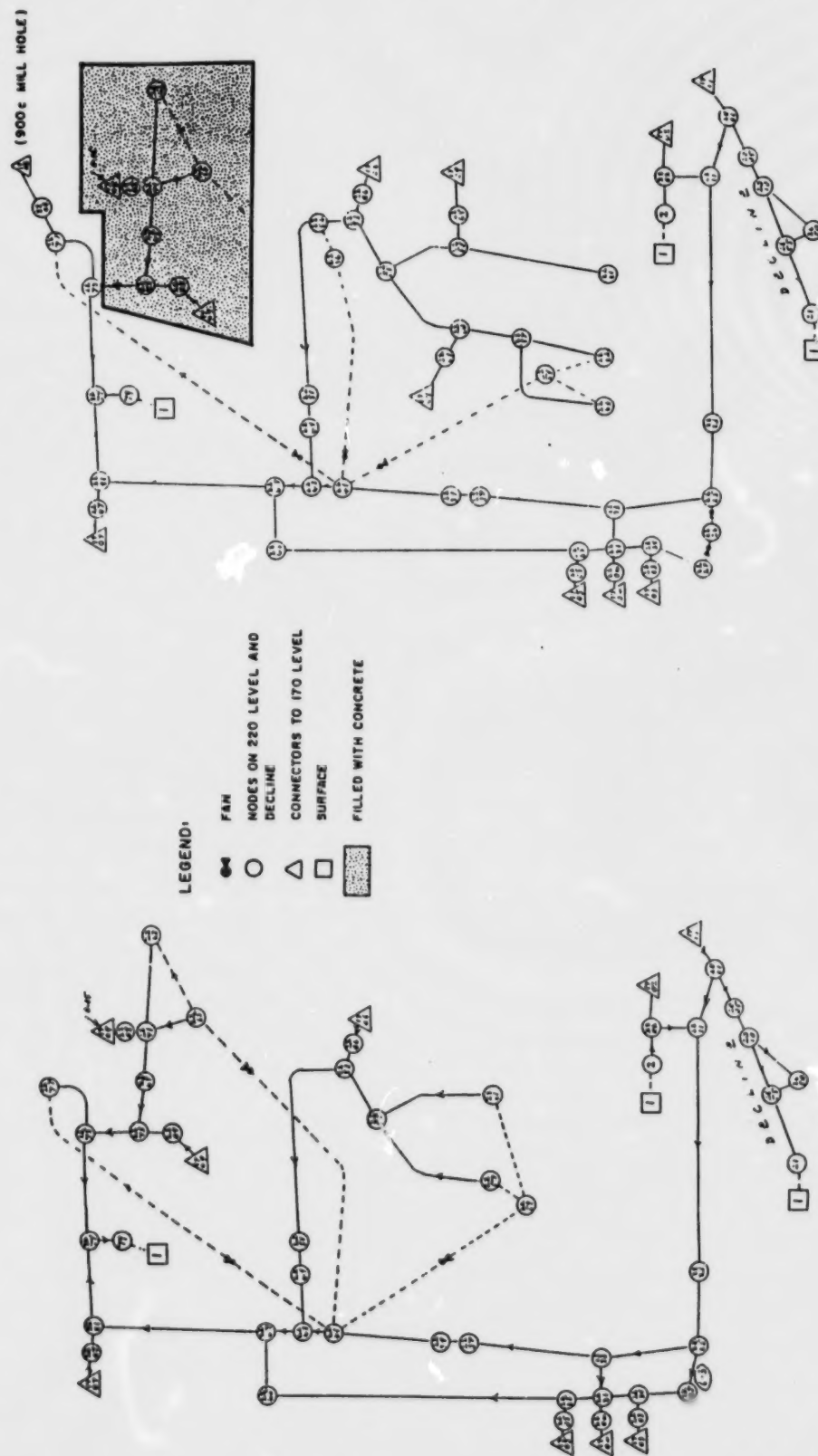
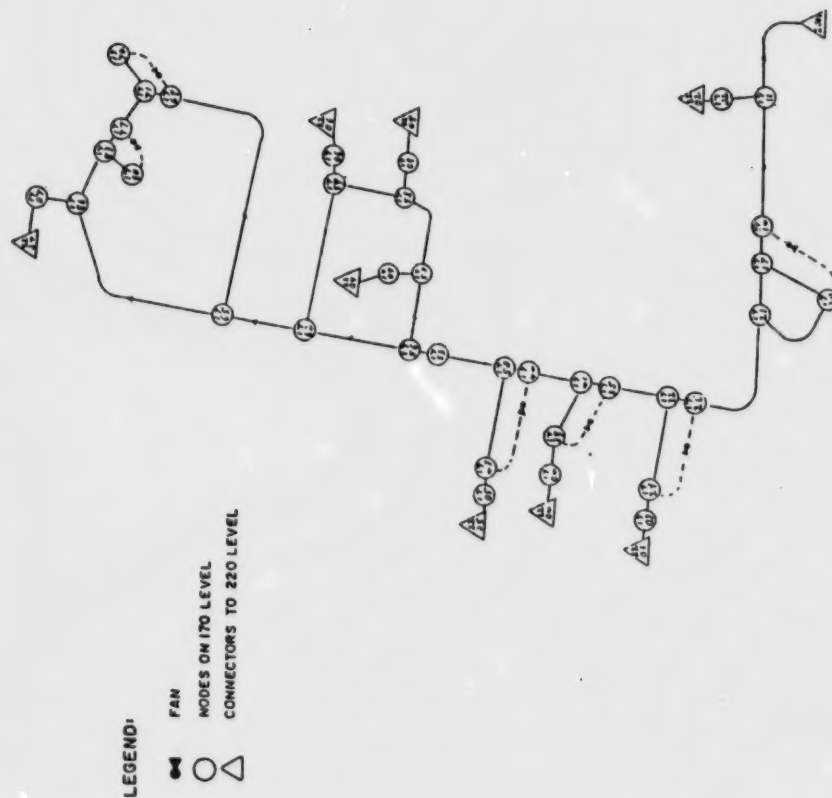
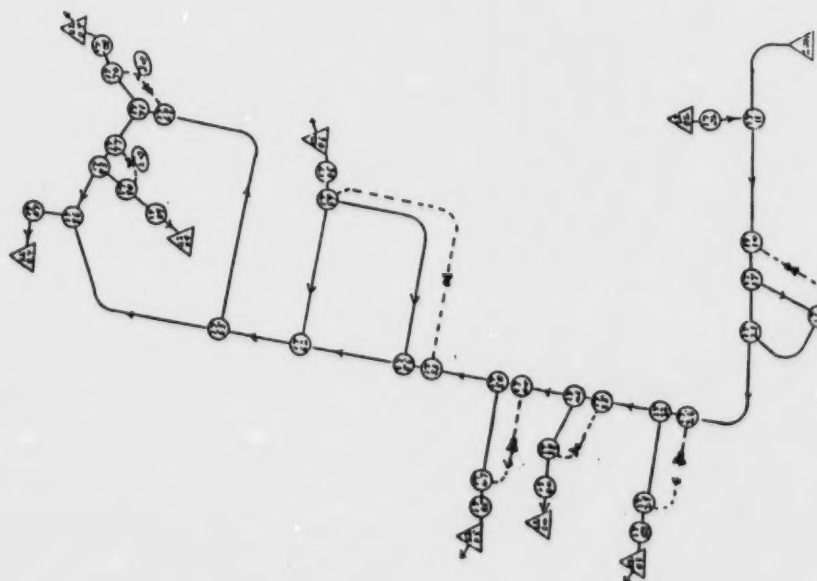


FIGURE 3.6
BRANCH NETWORKS FOR 170 LEVEL



A) 170 LEVEL AUGUST, 1986



B) 170 LEVEL OCTOBER, 1986

Equilibrium ("E") ratios representing the fractional ingrowth of radon daughters to the parent radon ranged from a low of 0.04, at the end of C South, to a high of 0.93 (i.e. 93% of equilibrium) on the Decline upstream of the main minewater sump.

In general terms, the results of the 5 August and 6 August measurements of radon gas concentrations were in close agreement with each other; however, at some locations the 7 August results were found to be higher than the radon concentrations measured on the previous two days (e.g. return air raise from 170 was 45 vs 21 pCi/L, and 835 Crosscut was 242 vs 104 pCi/L). This variation in radon concentrations between sampling days of a factor of 2 or so was also to be encountered in the two subsequent field programs. The variation was likely due to intermittent and rapid changes in ventilation distribution associated with flow reversal through mill holes, open air flow control doors and the like.

3.3.4 835 Crosscut Investigation

During the August 1986 field trip a special investigation was carried out in the 835 Crosscut to examine the variation in radon levels between consecutive locations in a stope. To accomplish this, the Crosscut was marked off in 5 metre intervals starting with Site #8-1 at the west end of the Crosscut. Radon gas measurements were made at 10 metre intervals at sites 8-1, 8-3, 8-5, etc. to 8-13 along the length of the Crosscut. Table 3.4 presents the results for each sampled location in the Crosscut. Gamma radiation levels were made at each of the 5 m intervals, midway between the sides of the tunnel and 1 m above the floor. Table 3.4 also presents the gamma results for the thirteen locations in the Crosscut. The levels range from a low of 0.0021 mSv/h to a high of 0.0079 mSv/h. The higher radiation field at 8-4 was attributable to a vein of uranium ore which intersected the Crosscut.

TABLE 3.4 : RESULTS OF 7 AUGUST 1986 835 CROSSCUT INVESTIGATION

SAMPLE SITE (1)	SAMPLE TIME	RADON (pCi/L)	GAMMA (mSv/h)
West End (2)			
8-1	10:00	205.6	0.0023
8-2			0.0028
8-3	10:00	174.6	0.0040
8-4			0.0079
8-5	10:15	242.1	0.0053
8-6			0.0024
8-7	10:15	212.8	0.0021
8-8			0.0035
8-9	10:20	267.7	0.0047
8-10			0.0052
8-11	10:30	177.1	0.0040
8-12			0.0052
8-13	10:40	115.9	0.0062
East End (2)			

NOTES:

1. Distance between grid point 5 metres
2. Direction of airflow from east to west
3. See Figure 2.2 for location of 835 Crosscut

North
M
A
I
N
W
A
Y
South

Airflow
West < ----- East

8-1 8-2 8-3 8-4 8-5 8-6 8-7 8-8 Etc.

The results of this investigation are discussed in Chapter 4.

3.4 October 1986 Field Campaign

3.4.1 Purpose and Duration

The second field visit to the mine took place from the 27th to the 31st of October 1986. The purpose of this field visit was to discuss the details of the sampling program with the Cluff Lake radiation protection personnel (at this time it was still planned for the Cluff Lake personnel to make routine measurements), to conduct a limited program of underground sampling, and to provide the Scientific Authority with an opportunity to examine the underground mining operation.

3.4.2 Mine Configuration

Subsequent to the August visit a number of changes had occurred at the mine. Figures 3.5 and 3.6 illustrate the 220 and 170 Level branch networks for both the August and October mine configurations respectively. The most notable of these changes on the 220 Level was the blocking off and sealing of the B&C North Workings, in preparation for the undercut and fill operation. B South and C South were extended and a small stope B2 had been added. With respect to the October branch network, the B,C North bulkheading eliminated the branches highlighted on Figure 3.5 and restructured the branches in the B,C South area. At the time of the October visit concrete work on C South had been completed and work was underway on B South, in preparation for an undercut and fill operation. The ventilation to C South had been shut off and the area was out-of-bounds to unauthorized personnel.

3.4.3 Results

Because of the limited time available on site, only two days of sampling could be accommodated. During these two days of intense sampling a total of forty one radon and thirty one corresponding radon daughter samples were collected at twenty seven different locations in the mine. Table 3.5 presents a summary of the results obtained during the October 1986 campaign, while Appendix Table A.2 presents the detailed calculations. The radon concentrations ranged from a low of 1.6 pCi/L in the Mainway near the A₃ South entrance, to a high of 370 pCi/L in room 3-15 where the ventilation had been shut off because the continuous mining machine had stopped operating. In general the radon levels in the mine were lower than during the August sampling campaign and only two samples were greater than 100 pCi/L.

Radon daughter levels ranged from less than 0.001 WL in the Mainway near the A3 South entrance, to a high of 1.49 WL in room 3-15. Radon daughter levels in general appeared to be comparable to those measured during the August 1986 campaign.

Equilibrium ratios between radon daughters and parent radon ranged from a low of 0.01 above the 170 sump, to a high of 0.42 at a site in the 835 Crosscut.

Similar to the August campaign as described in Section 3.3.3, some variation in radon concentration at the same sampling location was noted between the two sampling days (e.g. 170 return air raise at the 220 Level, 835 Crosscut at Site #8-1).

3.4.4 835 Crosscut Investigation

Once again a special sampling campaign was carried out in the 835 Crosscut. Because of the extended period over which the August

TABLE 3.5 : RADON AND RADON DAUGHTER RESULTS FOR OCTOBER 1986 CAMPAIGN
(CLUFF LAKE D-P MINE)

DATE	SITE #	LEVEL	SAMPLE LOCATION	RADON CONC (pCi/L)	RADON DTR'S (WL)	"E" RATIO
86-10-29	21.5	260	Decline Below 2nd Vent Door	2.9	0.001	0.03
86-10-29	20	170	Above 170 Sump	6.9	0.001	0.01
86-10-29	H1	220	A3 South Sill Enter	16.3	0.013	0.08
86-10-29	A1.5	220	Mainway Outside Lunchroom	4.1	N/A	-
86-10-29	CON	220	Concrete Pump Room by RAR	29.1	0.069	0.24
86-10-29	CM	220	Room 3-15/Contin. Miner Machine	128.1	0.242	0.19
86-10-29	414	220	Room 4-14	84.0	0.192	0.23
86-10-29	BS	220	B South & B2 South	80.4	0.074	0.09
86-10-29	BS	220	B2 South	15.4	0.010	0.07
86-10-29	A1	220	Mainway Past Sump, Near A3 South	1.6	0.000	-
86-10-29	835	220	835 X-Cut At 8-1	64.6	0.049	0.08
86-10-29	H2	220	A3 North Return Air	52.3	0.121	0.23
86-10-29	4	220	170 Return Air Raise At 220	19.2	0.024	0.12
86-10-29	3	220	Mainway Upstream 170 Exhaust	43.8	0.126	0.29
86-10-29	5	220	Mainway Before RAR To Surface	34.4	0.085	0.25
86-10-29	CON	220	Concrete Pump Room by RAR	27.4	0.054	0.20
86-10-29	835	220	835 X-Cut At 8-10	80.2	0.163	0.20
86-10-29	835	220	835 X-Cut At 8-8	72.4	0.124	0.17
86-10-29	835	220	835 X-Cut At 8-6	68.4	0.285	0.42
86-10-29	835	220	835 X-Cut At 8-4	72.8	0.123	0.17
86-10-29	835	220	835 X-Cut At 8-10	79.7	0.158	0.20
86-10-29	835	220	835 X-Cut At 8-8	75.0	0.228	0.30
86-10-29	835	220	835 X-Cut At 8-6	74.7	0.182	0.24
86-10-29	835	220	835 X-Cut At 8-4	77.1	0.196	0.25
86-10-29	19	279	Mine Exhaust Air At Surface	45.2	0.105	0.23
86-10-29	CON	220	Concrete Pump Room by RAR	23.7	0.046	0.19
86-10-30	20	170	Above 170 Sump	2.2	0.004	0.19
86-10-30	19	279	Mine Exhaust Air At Surface	46.7	0.092	0.20
86-10-30	21	260	Decline Before O-P Mine Access	2.4	0.002	0.08
86-10-30	835	220	835 X-Cut At 8-1	47.9	N/A	-
86-10-30	3	220	Mainway Upstream 170 Exhaust	44.2	N/A	-
86-10-30	4	220	170 Return Air Raise At 220	29.8	N/A	-
86-10-30	5	220	Mainway Before RAR To Surface	40.9	N/A	-
86-10-30	CM	220	Room 3-15/Contin. Miner Machine	369.7	1.486	0.40
86-10-30	BS	220	Link 22-55 TO 22-53	70.4	N/A	-
86-10-30	BS	220	Link 22-57 TO 22-55	58.3	N/A	-
86-10-30	BS	220	End Of B South	49.1	N/A	-
86-10-30	BS	220	B2 South At B2	4.8	N/A	-
86-10-30	20	170	Above 170 Sump	2.2	0.002	0.08
86-10-30	20.5	170	Link 17-23 to 17-26 *	3.9	0.006	0.15
86-10-30	20.5	170	Link 17-23 to 17-26 *	3.5	0.006	0.17

NOTE: * - Sampling done with cells in series.

See Table 3.2 for uncertainty associated with radon and radon daughter concentrations attributable to counting statistics.

samples were collected (30 to 40 minutes) and the conjecture that the variation in August radon results was due to fluctuations in radon levels during the sampling period it was decided that an attempt should be made to collect four simultaneous samples at four different locations in the Crosscut. To accomplish this objective, four sampling pump, scintillation cell and filter assemblies were suspended in the centre of the Crosscut (at a height of 1.0 to 1.5 metres above the floor) at Sites #8-4, 8-6, 8-8 and 8-10. To ensure that the same air mass was sampled, the pumps were turned on in sequence (from 8-10 to 8-4). A smoke tube was used to track the movement of the air mass in the stope as a visual indicator of when the air mass reached each sampling site. The test was carried out twice with similar results for both tests. The results of this special test are presented in Table 3.6.

3.5 October 1987 Field Campaign

3.5.1 Purpose and Duration

The third and final field visit to the mine took place from the 15th to the 23rd of October 1987. The purpose of this visit was to conduct as much sampling underground as the available time would accommodate, with particular emphasis on the parameters needed in the calculation of radon flux rates and the validation of the VENTRAD program.

3.5.2 Mine Configuration

A number of changes had occurred in the underground workings configuration since the last visit to the mine. Figure 3.7 depicts the 220 Level for October 1987 and Figure 3.8 the 170 Level. The most notable changes were the installation of ventilation doors in the Mainway just north of the 835 Crosscut,

TABLE 3.6 : RESULTS OF 29 OCTOBER 1986 835 CROSSCUT INVESTIGATION

SAMPLE SITE	SAMPLE TIME	RADON CONC (pCi/L)	RADON DTR'S (WL)	"E" RATIO

East				
8-10	17:45	80.22	0.1625	0.20
8-8	17:45	72.37	0.1242	0.17
8-6	17:46	68.41	0.2850	0.42
8-4	17:46	72.80	0.1225	0.17
West				
East				
8-10	18:00	79.69	0.1584	0.20
8-8	18:00	75.01	0.2281	0.30
8-6	18:01	74.72	0.1815	0.24
8-4	18:01	77.09	0.1955	0.25
West				

NOTE: Direction of airflow from east to west.

See Figure 2.2 for location of 835 Crosscut

FIGURE 3.7
220 LEVEL CONFIGURATION
DURING OCTOBER, 1987 CAMPAIGN

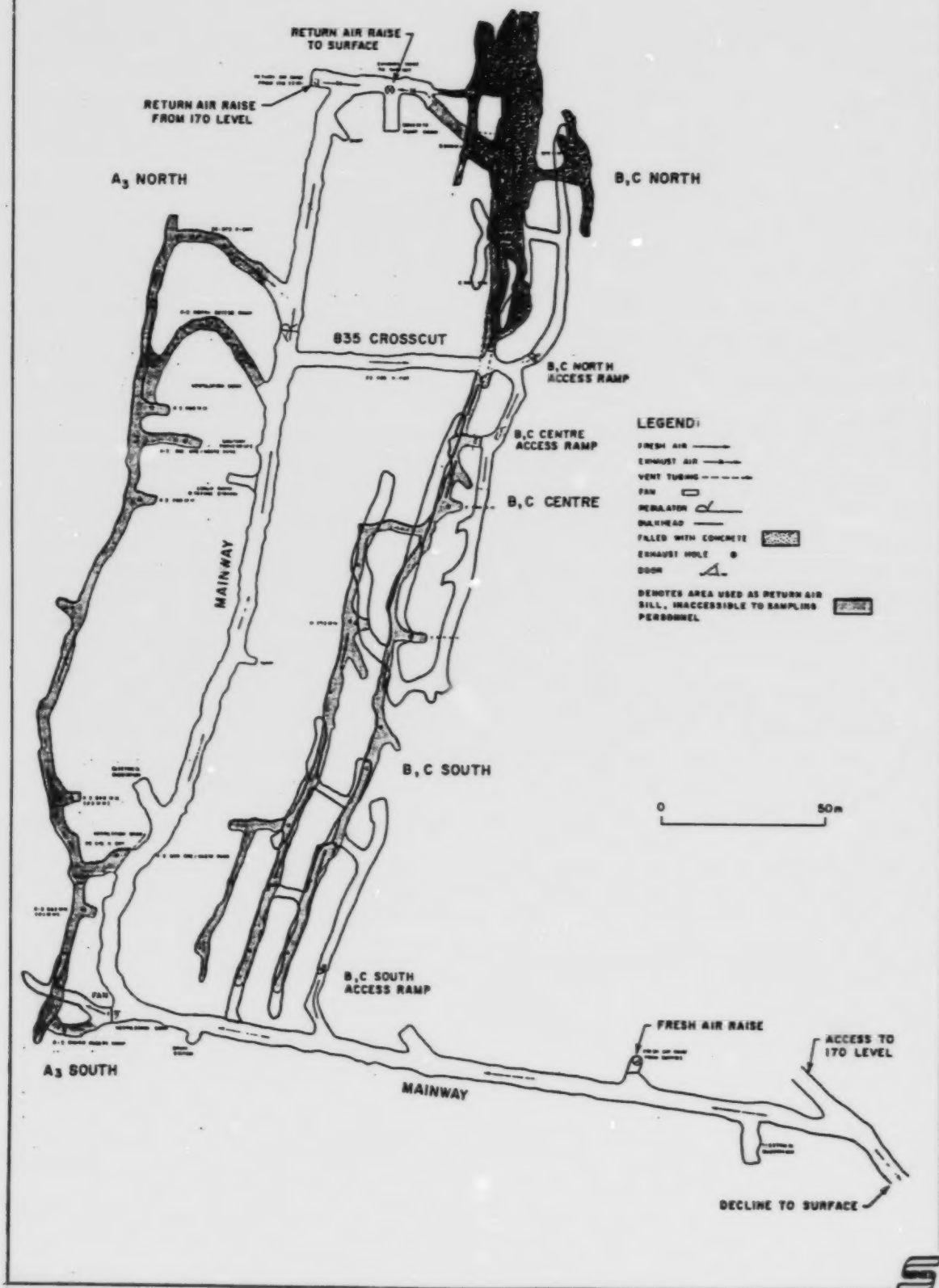
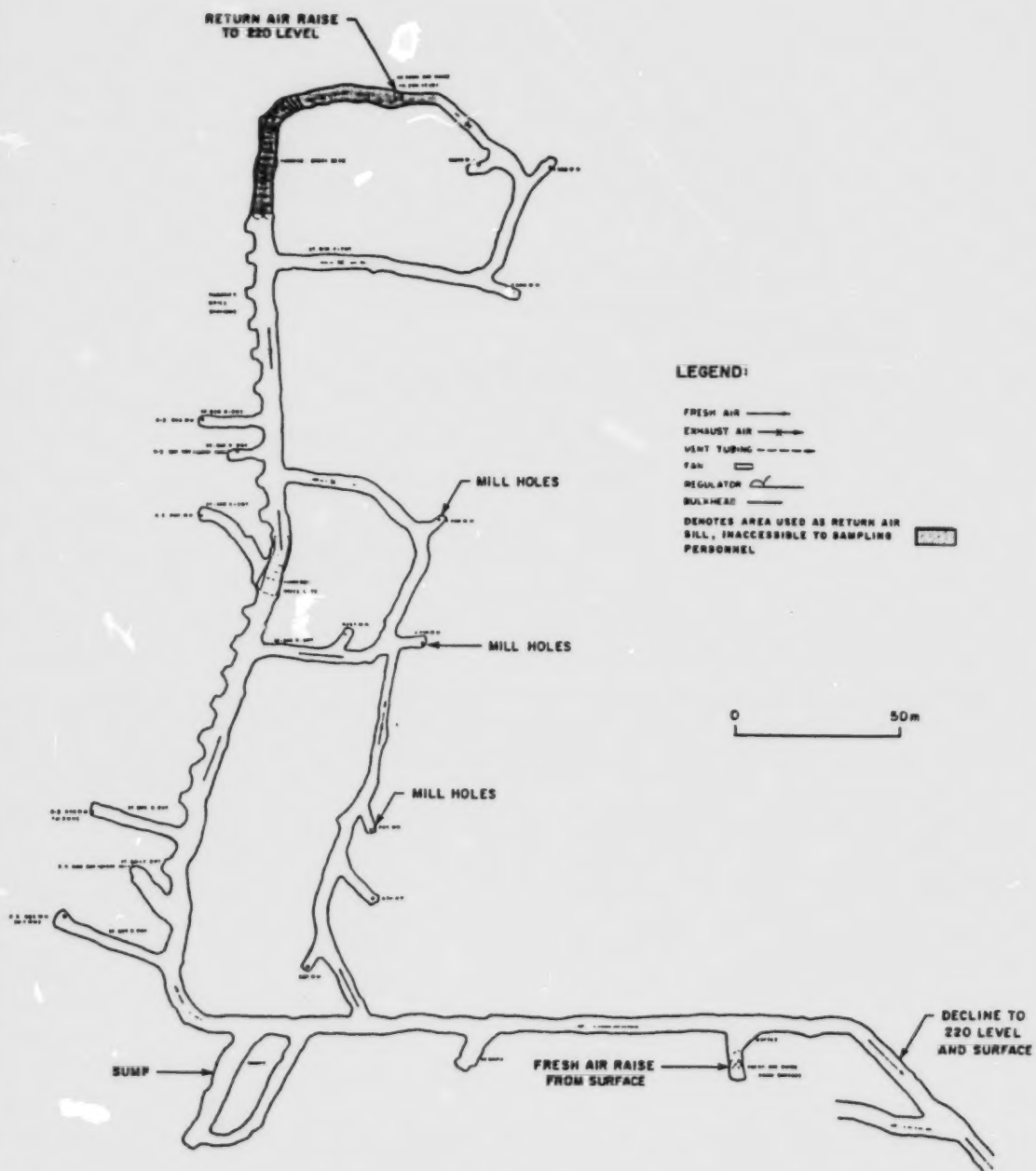


FIGURE 3.8
170 LEVEL CONFIGURATION
DURING OCTOBER, 1987 CAMPAIGN



and at the entrances to the B,C South (off Mainway) and the B,C, Centre and B,C, North areas of the mine (at east end of 835 Crosscut). The two sets of tandem 50 HP fans originally located in the Mainway near the lunchroom had been removed and reinstalled within the B,C, Centre and B,C, North workings.

Several cut and fill sequences had occurred since the October 1986 visit and as a result the stopes for the South and Centre workings at the 220 elevation, which were being actively mined during the two previous visits, were now connected to serve as an exhaust air sill/duct to the return air raise at the north end of the mine. Figure 3.9 outlines the use of the cut and partially filled areas as return air ducts. (It should be noted that this concept was in use during all three visits in the A section of the mine.) As a result of the revisions to the underground ventilation system the balanced network that the field team had brought to the site was no longer valid and the proposed sampling program had to be modified.

3.5.3 Results

During the seven days of sampling a total of one hundred and ten radon and fifty nine radon daughter samples were collected at twenty-nine different locations in the mine. Table 3.7 presents a summary of the results obtained during the October 1987 campaign, while Appendix Table A.3 presents the detailed calculations.

The radon concentrations ranged from a low of 0.3 pCi/L for the decline at the 220 Level (Site #22), to a high of about 605 pCi/L at the exit to Room 4-8 in the B,C North workings (Site #E2). Insufficient ventilation at the time of sampling resulted in this elevated radon level and the radon concentration for the same location the following day with ventilation in place was reduced

FIGURE 3.9
CUT AND FILL TECHNIQUE IN CROSS-SECTION
ILLUSTRATING VENTILATION SYSTEM

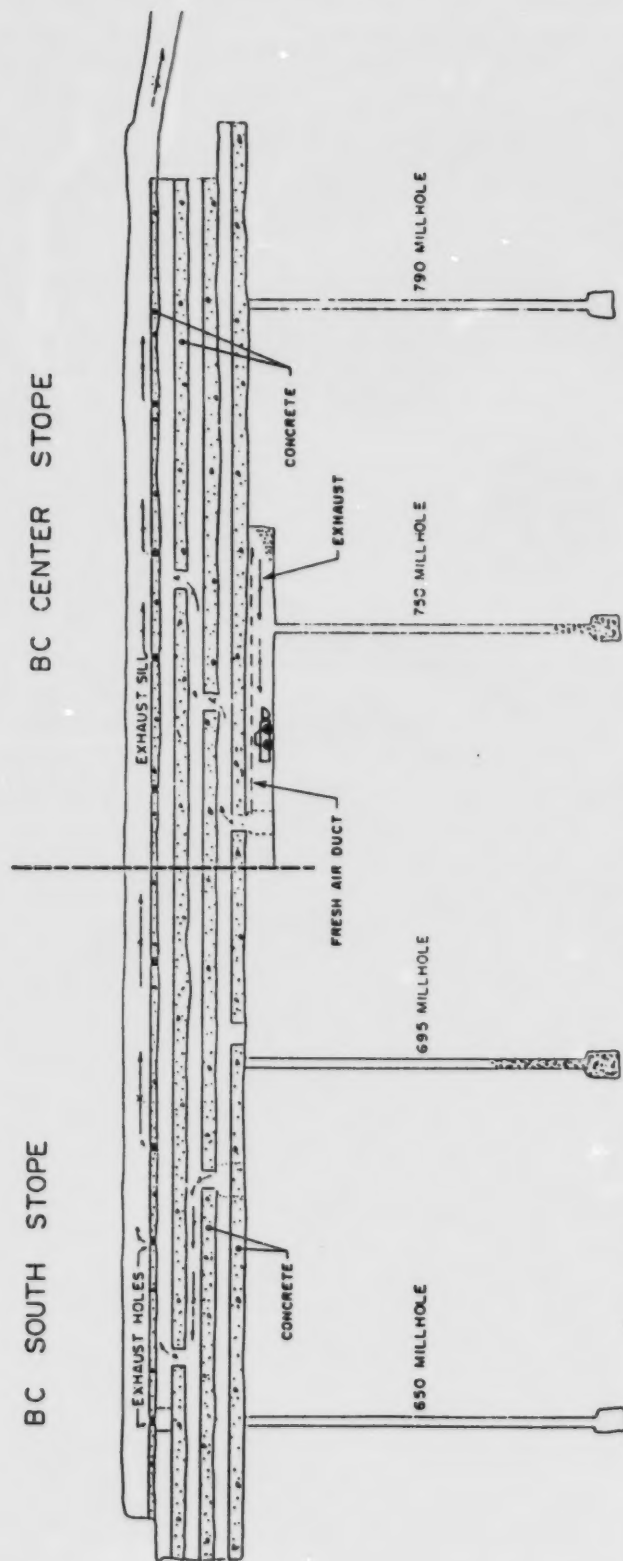


TABLE 3.7 : RADON AND RADON DAUGHTER RESULTS FOR OCTOBER 1987 CAMPAIGN
(CLUFF LAKE D-P MINE)

DATE	SITE #	LEVEL	SAMPLE LOCATION	RADON CONC (pCi/L)	RADON DTR'S (WL)	"E" RATIO
87-10-16	6	220	BC Sill Return Air At RAR, (VS#10)	212.3	N/A	-
87-10-16	4	220	170 Return Air Raise At 220 Level	363.3	N/A	-
87-10-16	A2	220	Mainway at 835 X-Cut	4.7	N/A	-
87-10-16	20	170	Above 170 Sump	10.8	N/A	-
87-10-17	A2.5	220	Mainway Vent Door Near 835 X-Cut	39.3	N/A	-
87-10-17	H2	220	A3 North Return Air	85.6	N/A	-
87-10-17	3	220	Mainway Upstream 170 Exhaust	82.0	N/A	-
87-10-17	4	220	170 Return Air Raise At 220 Level	43.5	N/A	-
87-10-17	5	220	Mainway Before RAR To Surface	65.9	N/A	-
87-10-17	6	220	BC Sill Return Air At RAR, (VS#10)	152.5	N/A	-
87-10-17	7	220	BC Sill Return Air At Sill Exit	150.2	N/A	-
87-10-17	A2	220	Mainway at 835 X-Cut	35.3	N/A	-
87-10-17	B2	220	835 X-Cut At B,C Split	32.4	N/A	-
87-10-17	10	220	BC Centre At Vent Doors	35.1	N/A	-
87-10-17	11	220	BC North At Vent Doors	51.3	N/A	-
87-10-17	12	220	BC North Ramp Drill Face	76.9	N/A	-
87-10-17	E2	220	BC North Room 4-8 Exit	604.7	N/A	-
87-10-17	D2	220	BC Centre-B North Exit	110.8	0.192	0.17
87-10-17	C2	220	BC Centre-C North Exit	214.3	0.373	0.17
87-10-17	16	220	BC Centre-Air To B North	35.3	0.119	0.34
87-10-17	A1	220	Mainway At A3 Access	36.5	N/A	-
87-10-17	H1	220	A3 South Sill Entrance	41.0	0.184	0.45
87-10-18	A1	220	Mainway At A3 Access	10.2	0.018	0.18
87-10-18	A2	220	Mainway at 835 X-Cut	11.1	0.026	0.23
87-10-18	B1	220	835 X-Cut At Mainway	9.8	0.029	0.30
87-10-18	B2	220	835 X-Cut At B,C Split	11.2	0.027	0.24
87-10-18	B2	220	835 X-Cut At B,C Split	12.1	0.027	0.22
87-10-18	C1	220	BC Centre-C North Face	66.7	0.047	0.07
87-10-18	C2	220	BC Centre-C North Exit	189.1	0.206	0.11
87-10-18	E1	220	BC North- Room 4-8 Face	63.8	0.088	0.14
87-10-18	E2	220	BC North Room 4-8 Exit	62.6	0.016	0.03
87-10-18	H2	220	A3 North Return Air	74.6	0.193	0.26
87-10-18	4	220	170 Return Air Raise At 220 Level	37.7	0.088	0.23
87-10-18	7	220	BC Sill Return Air At Sill Exit	125.8	0.234	0.19
87-10-18	5	220	Mainway Before RAR To Surface	55.7	0.122	0.22
87-10-18	H1	220	A3 South Sill Entrance	19.4	0.040	0.21
87-10-18	19	265	Mine Exhaust Air At Surface	107.0	0.192	0.18
87-10-19	H1	220	A3 South Sill Entrance	13.1	0.033	0.25
87-10-19	A1	220	Mainway At A3 Access	8.1	0.016	0.20
87-10-19	A2	220	Mainway at 835 X-Cut	6.4	0.015	0.24
87-10-19	B1	220	835 X-Cut At Mainway	9.2	0.026	0.28
87-10-19	B2	220	835 X-Cut At B,C Split	8.3	0.025	0.30
87-10-19	C1	220	BC Centre-C North Face	56.0	0.096	0.17
87-10-19	H2	220	A3 North Return Air	63.9	0.172	0.27
87-10-19	4	220	170 Return Air Raise At 220 Level	101.9	0.213	0.21
87-10-19	7	220	BC Sill Return Air At Sill Exit	149.1	0.227	0.15
87-10-19	5	220	Mainway Before RAR To Surface	84.7	0.175	0.21

TABLE 3.7 : CONTINUED

DATE	SITE #	LEVEL	SAMPLE LOCATION	RADON CONC (pCi/L)	RADON DTR'S (WL)	"E" RATIO
87-10-20	H1	220	A3 South Sill Entrance	17.1	0.026	0.15
87-10-20	A1	220	Mainway At A3 Access	5.4	0.010	0.18
87-10-20	A2	220	Mainway at 835 X-Cut	7.1	0.010	0.14
87-10-20	B1	220	835 X-Cut At Mainway	9.1	0.013	0.14
87-10-20	B2	220	835 X-Cut At B,C Split	12.2	0.017	0.14
87-10-20	F1	220	BC Centre- C North Face	66.2	0.089	0.13
87-10-20	F2	220	BC Centre- C North Exhaust	76.3	0.101	0.13
87-10-20	C1	220	BC Centre- C North Face	130.7	N/A	N/A
87-10-20	G1	220	BC North- C1 Face	95.4	0.072	0.08
87-10-20	G2	220	BC North- C1 Exhaust	102.4	0.075	0.07
87-10-20	H2	220	A3 North Return Air	74.3	0.210	0.28
87-10-20	4	220	170 Return Air Raise At 220 Level	83.6	0.131	0.16
87-10-20	7	220	BC Sill Return Air At Sill Exit	119.8	0.187	0.16
87-10-20	5	220	Mainway Before RAR To Surface	66.8	0.130	0.19
87-10-20	19	265	Mine Exhaust Air At Surface	92.6	0.166	0.18
87-10-20	19	265	Mine Exhaust Air At Surface	97.3	0.166	0.17
87-10-21	H1	220	A3 South Sill Entrance	17.4	N/A	-
87-10-21	A1	220	Mainway At A3 Access	5.8	N/A	-
87-10-21	A2	220	Mainway at 835 X-Cut	10.7	N/A	-
87-10-21	B1	220	835 X-Cut At Mainway	10.7	N/A	-
87-10-21	B2	220	835 X-Cut At B,C Split	11.9	N/A	-
87-10-21	C1	220	BC Centre-CX,CY Face	46.6	N/A	-
87-10-21	C2	220	BC Centre-CX,CY Exhaust	61.0	N/A	-
87-10-21	F1	220	BC Centre- C North Face	104.0	N/A	-
87-10-21	F2	220	BC Centre- C North Exhaust	260.0	N/A	-
87-10-21	G2	220	BC North- C1 Exhaust	199.7	N/A	-
87-10-21	H2	220	A3 North Return Air	71.5	N/A	-
87-10-21	4	220	170 Return Air Raise At 220 Level	56.9	N/A	-
87-10-21	7	220	BC Sill Return Air At Sill Exit	126.1	N/A	-
87-10-21	5	220	Mainway Before RAR To Surface	58.4	N/A	-
87-10-21	G1	220	BC North- C1 Face	109.2	N/A	-
87-10-21	G2	220	BC North- C1 Exhaust	77.7	N/A	-
87-10-21	F1	220	BC Centre- C North Face	177.7	0.207	0.12
87-10-21	F2	220	BC Centre- C North Exhaust	112.0	0.121	0.11
87-10-21	C2	220	BC Centre-CX,CY Exhaust	78.5	0.107	0.14
87-10-21	C1	220	BC Centre-CX,CY Face	60.4	0.057	0.09
87-10-21	D1	220	BC Centre- B North Face	39.9	0.071	0.18
87-10-21	D2	220	BC Centre- B North Exhaust	92.7	0.099	0.11
87-10-21	G1	220	BC North- C1 Face	114.6	0.087	0.08
87-10-21	G2	220	BC North- C1 Exhaust	146.9	0.100	0.07
87-10-21	21	265	Decline Exhaust At Surface	3.2	N/A	-
87-10-21	19	265	Mine Exhaust Air At Surface	166.5	0.221	0.13

TABLE 3.7 : CONTINUED

DATE	SITE #	LEVEL	SAMPLE LOCATION	RADON CONC (pCi/L)	RADON DTR'S (WL)	"E" RATIO
87-10-22	H1	220	A3 South Sill Entrance	14.8	N/A	-
87-10-22	A1	220	Mainway At A3 Access	7.9	N/A	-
87-10-22	A2	220	Mainway at 835 X-Cut	6.5	0.011	0.17
87-10-22	B1	220	835 X-Cut At Mainway	8.4	N/A	-
87-10-22	B2	220	835 X-Cut At B,C Split	8.3	N/A	-
87-10-22	D1	220	BC Centre- B North Face	102.1	0.063	0.06
87-10-22	D2	220	BC Centre- B North Exhaust	79.5	N/A	-
87-10-22	F1	220	BC Centre- C North Face	83.8	N/A	-
87-10-22	F2	220	BC Centre- C North Exhaust	60.3	N/A	-
87-10-22	C1	220	BC Centre-CX,CY Face	47.0	0.052	0.11
87-10-22	C2	220	BC Centre-CX,CY Exhaust	62.8	N/A	-
87-10-22	G2	220	BC North- C1 Exhaust	62.4	N/A	-
87-10-22	G1	220	BC North- C1 Face	127.6	0.061	0.05
87-10-22	H2	220	A3 North Return Air	77.1	N/A	-
87-10-22	4	220	170 Return Air Raise At 220 Level	59.6	0.164	0.28
87-10-22	7	220	BC Sill Return Air At Sill Exit	132.4	0.381	0.29
87-10-22	5	220	Mainway Before RAR To Surface	76.2	N/A	-
87-10-22	20	170	Above 170 Sump	4.2	N/A	-
87-10-22	22	220	Decline At 170/220 Split	0.3	N/A	-
87-10-22	21	265	Decline Exhaust At Surface	3.9	N/A	-
87-10-22	19	265	Mine Exhaust Air At Surface	110.7	0.212	0.19

Note: See Table 3.2 for uncertainty associated with radon and radon daughter concentrations attributable to counting statistics.

to about 63 pCi/L. In general the radon levels measured during this visit were slightly higher on an overall basis than those measured during the October 1986 campaign.

Measured radon daughter levels ranged from a low of 0.010 WL in the Mainway at the A3 South access to a high of 0.38 WL for the B,C Sill return air at the Sill exit near the RAR to surface. Radon daughter levels appeared to be similar to those measured during the two previous campaigns.

Equilibrium ratios between radon daughters and parent radon ranged from a low of 0.03 at site E2 to a high of 0.45 at the entrance to the A3 sill.

3.5.4 B South Breakthrough

On the first day of sampling for this campaign (16 October) access to the B,C, South workings was via the ventilation door shown on Figure 3.7. The radon concentration in the Mainway at the 835 Crosscut was 4.7 pCi/L, which was considered to be consistent with the two previous campaigns. However, during the evening shift of 16 October '87 the rock wall separating the B South stope from the Mainway was broken through, thereby creating a short circuit in the B,C sill ventilation system. As a result the radon levels in the Mainway were measured on 17 October at 15 pCi/L. The installation of a bulkhead at the location of the break-through took several days to complete and it was not until 20 October that Mainway radon concentrations were returned to pre break-through levels. The impact of this somewhat elevated "fresh" air concentration was in evidence throughout the mine on 17 October; however, during the ensuing days this impact became less and less evident as the bulkhead was completed and the Mainway radon concentration returned to more typical levels.

4.0 INTERPRETATION OF DATA

4.1 Sample Site Identification and Location

To assist in the compilation and interpretation of the radon and radon daughter data collected during the three field campaigns a sample site number was assigned to each sample result. Samples collected for the express purpose of generating radon flux values were prefixed by a letter representing the section of the mine tested (e.g. A through to H), followed by the number "1" (representing the inlet) or "2" (representing the outlet of the section). Other results were simply coded with either letters or numbers to make identification and collation of results easier. These results in concert with the section results were used to monitor the operation of the underground facility and as validation/input values for the VENTRAD program (see Chapter 5). Illustrative data are shown on Table 4.1 for sampling Site #4, the 170 return air raise as it entered the 220 Level. The data show a wide variation in radon concentration, ranging from a low of 19 pCi/L on 27 October 1986 to a high of 363 pCi/L on 16 October 1987. The variation at this site appeared to be attributable to the quantity and quality of ore present at the mill holes on the 170 Level.

Table 4.2 presents a summary of all the radon and radon daughter data collected during the three campaigns. It has been arranged by sampling site number for ease of reference. A total of 195 radon and 131 radon daughter results are presented on the Table. Figures 4.1 and 4.2 illustrate the sampling locations on the 220 and 170 Levels respectively.

FIGURE 4.1
SAMPLE SITE LOCATIONS
ON 220 LEVEL

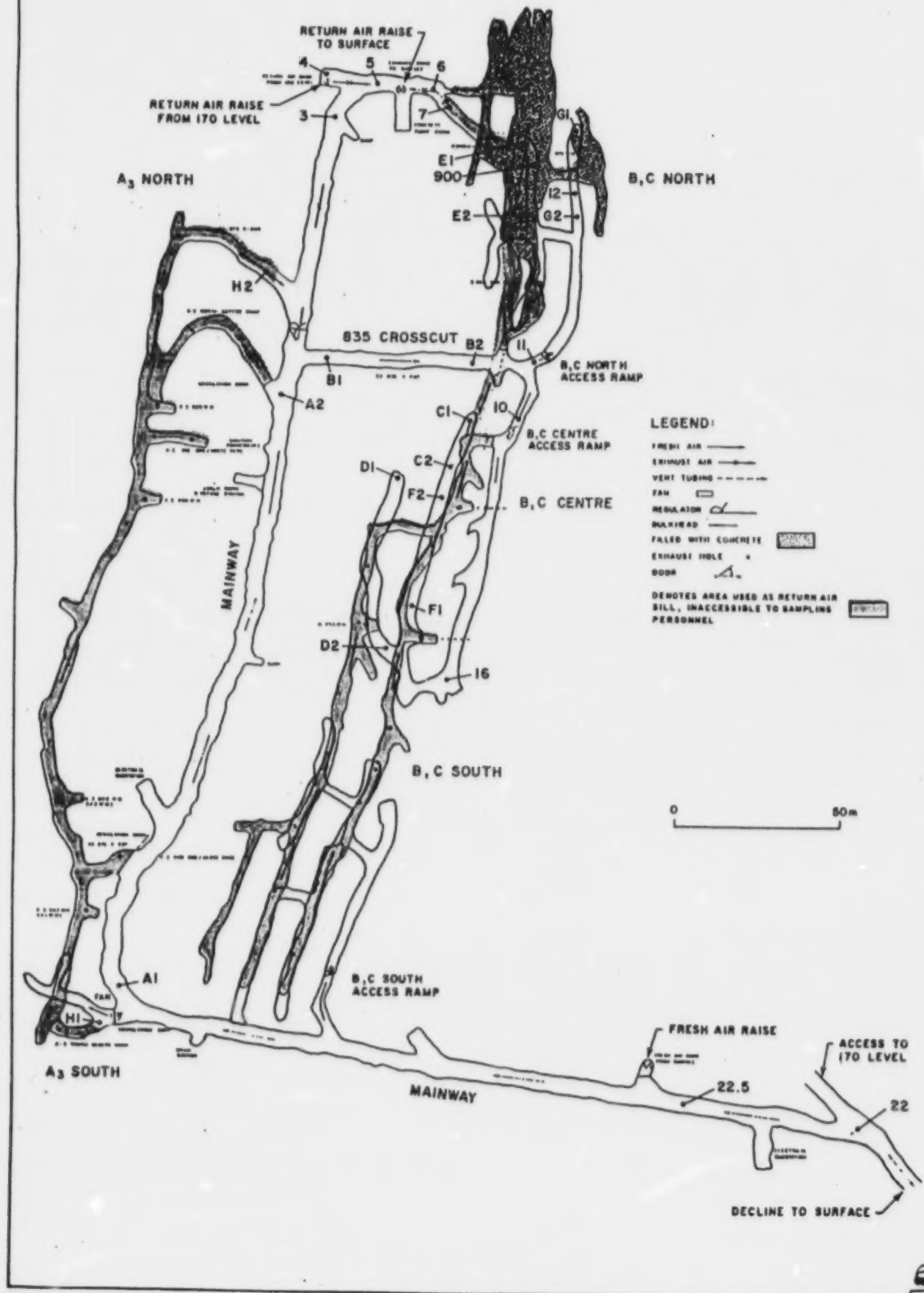


FIGURE 4.2
SAMPLE SITE LOCATIONS
ON 170 LEVEL



TABLE 4.1 : MONITORING SITE #4 RADON AND RADON DAUGHTER RESULTS SUMMARY
(170 Return Air Raise At 220 Level)

DATE	CAMPAIGN	RADON CONC (pCi/L)	RADON DTR'S (WL)	"E" RATIO
86-08-06	1	21.3	0.048	0.23
86-08-07	1	44.8	0.067	0.15
86-10-29	2	19.2	0.024	0.12
86-10-30	2	29.8	N/A	-
87-10-16	3	363.3	N/A	-
87-10-17	3	43.5	N/A	-
87-10-18	3	37.7	0.088	0.23
87-10-19	3	101.9	0.213	0.21
87-10-20	3	83.6	0.131	0.16
87-10-21	3	56.9	N/A	-
87-10-22	3	59.6	0.164	0.28

TABLE 4.2 : RADON AND RADON DAUGHTER RESULTS SUMMARY
(3 FIELD CAMPAIGNS)

DATE	SITE #	LEVEL	SAMPLE LOCATION	RADON CONC (pCi/L)	RADON DTR'S (WL)	"E" RATIO
87-10-17	10	220	BC Centre At Vent Doors	35.1	N/A	-
87-10-17	11	220	BC North At Vent Doors	51.3	N/A	-
87-10-17	12	220	BC North Ramp Drill Face	76.9	N/A	-
87-10-17	16	220	BC Centre-Air To B North	35.3	0.119	0.34
86-10-29	19	279	Mine Exhaust Air At Surface	45.2	0.105	0.23
86-10-30	19	279	Mine Exhaust Air At Surface	46.7	0.092	0.20
87-10-18	19	265	Mine Exhaust Air At Surface	107.0	0.192	0.18
87-10-20	19	265	Mine Exhaust Air At Surface	97.3	0.192	0.17
87-10-20	19	265	Mine Exhaust Air At Surface	92.6	0.166	0.18
87-10-21	19	265	Mine Exhaust Air At Surface	166.5	0.221	0.13
87-10-22	19	265	Mine Exhaust Air At Surface	110.7	0.212	0.19
86-08-05	20	170	Above 170 Sump	4.1	N/A	-
86-10-29	20	170	Above 170 Sump	6.9	0.001	0.01
86-10-30	20	170	Above 170 Sump	2.2	0.004	0.19
86-10-30	20	170	Above 170 Sump	2.2	0.002	0.08
87-10-16	20	170	Above 170 Sump	10.8	N/A	-
87-10-22	20	170	Above 170 Sump	4.2	N/A	-
86-08-05	20.5	170	Mainway Downstream Of Sump	3.4	N/A	-
86-08-07	20.5	170	Decline Upstream of Sump (VS#2)	1.1	0.010	0.93
86-10-30	20.5	170	Link 17-23 to 17-26 *	3.9	0.006	0.15
86-10-30	20.5	170	Link 17-23 to 17-26 *	3.5	0.006	0.17
86-08-06	21	260	Decline Remuck #1 (Near Top)	3.8	0.008	0.21
86-10-30	21	260	Decline Before O-P Mine Access	2.4	0.002	0.08
87-10-21	21	265	Decline Exhaust At Surface	3.2	N/A	-
87-10-22	21	220	Decline Exhaust At Surface	3.9	N/A	-
86-08-06	21.5	260	Decline Between Vent Doors	1.5	0.002	0.13
86-10-29	21.5	260	Decline Below 2nd Vent Door	2.9	0.001	0.03
86-08-06	22	220	Decline at 170/220 Split	0.3	<.001	-
87-10-22	22	220	Decline at 220 Level	0.3	N/A	-
86-08-06	22.5	220	Mainway By FAR (Vent Stat.#2)	0.1	<.001	-
86-08-06	3	220	Mainway Upstream 170 Exhaust	96.0	0.088	0.09
86-10-29	3	220	Mainway Upstream 170 Exhaust	43.8	0.126	0.29
86-10-30	3	220	Mainway Upstream 170 Exhaust	44.2	N/A	-
87-10-17	3	220	Mainway Upstream 170 Exhaust	82.0	N/A	-
86-08-06	4	220	170 Return Air Raise At 220 Level	21.3	0.048	0.23
86-08-07	4	220	170 Return Air Raise At 220 Level	44.8	0.067	0.15
86-10-29	4	220	170 Return Air Raise At 220 Level	19.2	0.024	0.12
86-10-30	4	220	170 Return Air Raise At 220 Level	29.8	N/A	-
87-10-16	4	220	170 Return Air Raise At 220 Level	363.3	N/A	-
87-10-17	4	220	170 Return Air Raise At 220 Level	43.5	N/A	-
87-10-18	4	220	170 Return Air Raise At 220 Level	37.7	0.088	0.23
87-10-19	4	220	170 Return Air Raise At 220 Level	101.9	0.213	0.21
87-10-20	4	220	170 Return Air Raise At 220 Level	83.6	0.131	0.16
87-10-21	4	220	170 Return Air Raise At 220 Level	56.9	N/A	-
87-10-22	4	220	170 Return Air Raise At 220 Level	59.6	0.164	0.28

TABLE 4.2 : CONTINUED

DATE	SITE #	LEVEL	SAMPLE LOCATION	RADON CONC (pCi/L)	RADON DTR'S (WL)	"E" RATIO
86-10-29	414	220	Room 4-14	84.0	0.192	0.23
86-08-06	5	220	Mainway Before RAR To Surface	98.6	0.061	0.06
86-10-29	5	220	Mainway Before RAR To Surface	34.4	0.085	0.25
86-10-30	5	220	Mainway Before RAR To Surface	40.9	N/A	-
87-10-18	5	220	Mainway Before RAR To Surface	55.7	0.122	0.22
87-10-19	5	220	Mainway Before RAR To Surface	84.7	0.175	0.21
87-10-20	5	220	Mainway Before RAR To Surface	66.8	0.130	0.19
87-10-21	5	220	Mainway Before RAR To Surface	58.4	N/A	-
87-10-22	5	220	Mainway Before RAR To Surface	76.2	N/A	-
87-10-17	5	220	Mainway Before RAR To Surface	65.9	N/A	-
86-08-06	6	220	BC Sill Return Air At RAR, (VS#10)	58.5	0.040	0.07
87-10-16	6	220	BC Sill Return Air At RAR, (VS#10)	212.3	N/A	-
87-10-17	6	220	BC Sill Return Air At RAR, (VS#10)	152.5	N/A	-
87-10-17	7	220	BC Sill Return Air At Sill Exit	150.2	N/A	-
87-10-18	7	220	BC Sill Return Air At Sill Exit	125.8	0.234	0.19
87-10-19	7	220	BC Sill Return Air At Sill Exit	149.1	0.227	0.15
87-10-20	7	220	BC Sill Return Air At Sill Exit	119.8	0.187	0.16
87-10-21	7	220	BC Sill Return Air At Sill Exit	126.1	N/A	-
87-10-22	7	220	BC Sill Return Air At Sill Exit	132.4	0.381	0.29
86-08-07	746	170	17-59 to 17-62 (746 X-Cut)	14.4	0.012	0.08
86-08-07	746	170	17-59 to 17-56 (746 X-Cut)	10.9	0.013	0.12
86-08-05	835	220	835 X-Cut at Mainway	46.4	0.047	0.10
86-08-06	835	220	835 X-Cut at B,C Split (VS#6)	59.9	0.050	0.08
86-08-06	835	220	835 X-Cut (Vent Stat.#5)	104.4	0.080	0.08
86-08-07	835	220	835 Cross-cut at 8-1	205.6	0.153	0.07
86-08-07	835	220	835 Cross-cut at 8-3	174.6	0.172	0.10
86-08-07	835	220	835 Cross-cut at 8-5	242.1	0.172	0.07
86-08-07	835	220	835 Cross-cut at 8-7	212.8	0.230	0.11
86-08-07	835	220	835 Cross-cut at 8-9	267.7	0.170	0.06
86-08-07	835	220	835 Cross-cut at 8-11	177.1	0.254	0.14
86-08-07	835	220	835 Cross-cut at 8-13	115.9	0.166	0.14
86-10-29	835	220	835 X-Cut At 8-1	64.6	0.049	0.08
86-10-30	835	220	835 X-Cut At 8-1	47.9	N/A	-
86-10-29	835	220	835 X-Cut At 8-10	79.7	0.158	0.20
86-10-29	835	220	835 X-Cut At 8-10	80.2	0.163	0.20
86-10-29	835	220	835 X-Cut At 8-8	72.4	0.124	0.17
86-10-29	835	220	835 X-Cut At 8-8	75.0	0.228	0.30
86-10-29	835	220	835 X-Cut At 8-6	74.7	0.182	0.24
86-10-29	835	220	835 X-Cut At 8-6	68.4	0.285	0.42
86-10-29	835	220	835 X-Cut At 8-4	72.8	0.123	0.17
86-10-29	835	220	835 X-Cut At 8-4	77.1	0.196	0.25
86-08-07	900	170	900 C Mill Hole (17-08)	20.0	0.018	0.09
86-08-07	900	220	900 C Mill Hole (22-08)	8879.6	4.138	0.05
86-08-07	900	220	900 C Mill Hole (22-08)	355.2	0.387	0.11

TABLE 4.2 : CONTINUED

DATE	SITE #	LEVEL	SAMPLE LOCATION	RADON CONC (pCi/L)	RADON DTR'S (WL)	"E" RATIO
86-08-05	BN	220	22-73 to 22-75 (B North, VS#9)	221.1	0.168	0.08
86-08-06	BN	220	22-73 to 22-75 (B North, VS#9)	236.9	0.132	0.06
86-08-06	BS	220	B -South End (Vent Stat.#16)	42.3	0.020	0.05
86-10-29	BS	220	B South & B2 South	80.4	0.074	0.09
86-10-29	BS	220	B2 South	15.4	0.010	0.07
86-10-30	BS	220	Link 22-55 TO 22-53	70.4	N/A	-
86-10-30	BS	220	B2 South At B2	4.8	N/A	-
86-10-30	BS	220	Link 22-57 TO 22-55	58.3	N/A	-
86-10-30	BS	220	End Of B South	49.1	N/A	-
86-10-29	CM	220	Room 3-15/Contin. Miner Machine	128.1	0.242	0.19
86-10-30	CM	220	Room 3-15/Contin. Miner Machine	369.7	1.486	0.40
86-08-05	CN	220	22-71 to 22-69 (C1 SILL)	171.5	0.156	0.09
86-08-06	CN	220	22-71 to 22-69 (C NORTH, VS#8)	144.6	0.123	0.09
86-10-29	CON	220	Concrete Pump Room by RAR	27.4	0.054	0.20
86-10-29	CON	220	Concrete Pump Room by RAR	29.1	0.069	0.24
86-10-29	CON	220	Concrete Pump Room by RAR	23.7	0.046	0.19
86-08-06	CS	220	C -South End (Vent. Stat.#15)	58.7	0.026	0.04
86-08-05	LUN	220	Inside Lunchroom	4.2	N/A	-

FLUX SECTION SITES

86-08-05	A1	220	2nd Electrical Substation	3.3	N/A	-
86-08-06	A1	220	Mainway by Sump & A3 South Access	3.5	0.003	0.09
86-08-07	A1	220	Mainway After Sump, Near A3 South	1.6	0.001	0.06
86-08-07	A1	220	Mainway Before Sump, Near A3 South	1.3	0.001	0.08
86-10-29	A1	220	Mainway Past Sump, Near A3 South	1.6	-	-
87-10-17	A1	220	Mainway At A3 South Access	36.5	N/A	-
87-10-18	A1	220	Mainway At A3 South Access	10.2	0.018	0.18
87-10-19	A1	220	Mainway At A3 South Access	8.1	0.016	0.20
87-10-20	A1	220	Mainway At A3 South Access	5.4	0.010	0.18
87-10-21	A1	220	Mainway At A3 South Access	5.8	N/A	-
87-10-22	A1	220	Mainway At A3 South Access	7.9	N/A	-
86-08-05	A1.5	220	Mainway Outside Lunchroom	5.1	N/A	-
86-08-06	A1.5	220	Mainway Outside Lunchroom	4.8	0.007	0.15
86-10-29	A1.5	220	Mainway Outside Lunchroom	4.1	N/A	-
87-10-16	A2	220	Mainway at 835 X-Cut	4.7	N/A	-
87-10-17	A2	220	Mainway Vent Door By 835 X-Cut	39.3	N/A	-
87-10-17	A2	220	Mainway at 835 X-Cut	35.3	N/A	-
87-10-18	A2	220	Mainway at 835 X-Cut	11.1	0.026	0.23
87-10-19	A2	220	Mainway at 835 X-Cut	6.4	0.015	0.24
87-10-20	A2	220	Mainway at 835 X-Cut	7.1	0.010	0.14
87-10-21	A2	220	Mainway at 835 X-Cut	10.7	N/A	-
87-10-22	A2	220	Mainway at 835 X-Cut	6.5	0.011	0.17

TABLE 4.2 : CONTINUED

DATE	SITE #	LEVEL	SAMPLE LOCATION	RADON CONC (pCi/L)	RADON DTR'S (WL)	"E" RATIO
87-10-18	B1	220	835 X-Cut At Mainway	9.8	0.029	0.30
87-10-19	B1	220	835 X-Cut At Mainway	9.2	0.026	0.28
87-10-20	B1	220	835 X-Cut At Mainway	9.1	0.013	0.14
87-10-21	B1	220	835 X-Cut At Mainway	10.7	N/A	-
87-10-22	B1	220	835 X-Cut At Mainway	8.4	N/A	-
87-10-17	B2	220	835 X-Cut At B,C Split	32.4	N/A	-
87-10-18	B2	220	835 X-Cut At B,C Split	12.1	0.027	0.22
87-10-18	B2	220	835 X-Cut At B,C Split	11.2	0.027	0.24
87-10-19	B2	220	835 X-Cut At B,C Split	8.3	0.025	0.30
87-10-20	B2	220	835 X-Cut At B,C Split	12.2	0.017	0.14
87-10-21	B2	220	835 X-Cut At B,C Split	11.9	N/A	-
87-10-22	B2	220	835 X-Cut At B,C Split	8.3	N/A	-
87-10-18	C1	220	BC Centre-C North Face	66.7	0.047	0.07
87-10-19	C1	220	BC Centre-C North Face	56.0	0.096	0.17
87-10-20	C1	220	BC Centre-C North Face	130.7	N/A	N/A
87-10-21	C1	220	BC Centre-CX,CY Face	46.6	N/A	-
87-10-21	C1	220	BC Centre-CX,CY Face	60.4	0.057	0.09
87-10-22	C1	220	BC Centre-CX,CY Face	47.0	0.052	0.11
87-10-17	C2	220	BC Centre-C North Exit	214.3	0.373	0.17
87-10-18	C2	220	BC Centre-C North Exit	189.1	0.206	0.11
87-10-21	C2	220	BC Centre-CX,CY Exhaust	78.5	0.107	0.14
87-10-21	C2	220	BC Centre-CX,CY Exhaust	61.0	N/A	-
87-10-22	C2	220	BC Centre-CX,CY Exhaust	62.8	N/A	-
87-10-21	D1	220	BC Centre- B North Face	39.9	0.071	0.18
87-10-22	D1	220	BC Centre- B North Face	102.1	0.063	0.06
87-10-17	D2	220	BC Centre-B North Exit	110.8	0.192	0.17
87-10-21	D2	220	BC Centre- B North Exhaust	92.7	0.099	0.11
87-10-22	D2	220	BC Centre- B North Exhaust	79.5	N/A	-
87-10-18	E1	220	BC North- Room 4-8 Face	63.8	0.088	0.14
87-10-17	E2	220	BC North Room 4-8 Exit	604.7	N/A	-
87-10-18	E2	220	BC North Room 4-8 Exit	62.6	0.016	0.03
87-10-20	F1	220	BC Centre- C North Face	66.2	0.089	0.13
87-10-21	F1	220	BC Centre- C North Face	104.0	N/A	-
87-10-21	F1	220	BC Centre- C North Face	177.7	0.207	0.12
87-10-22	F1	220	BC Centre- C North Face	83.8	N/A	-
87-10-20	F2	220	BC Centre- C North Exhaust	76.3	0.101	0.13
87-10-21	F2	220	BC Centre- C North Exhaust	260.0	N/A	-
87-10-21	F2	220	BC Centre- C North Exhaust	112.0	0.121	0.11
87-10-22	F2	220	BC Centre- C North Exhaust	60.3	N/A	-

TABLE 4.2 : CONTINUED

DATE	SITE #	LEVEL	SAMPLE LOCATION	RADON CONC (pCi/L)	RADON DTR'S (WL)	"E" RATIO
87-10-20	G1	220	BC North- C1 Face	95.4	0.072	0.08
87-10-21	G1	220	BC North- C1 Face	109.2	N/A	-
87-10-21	G1	220	BC North- C1 Face	114.6	0.087	0.08
87-10-22	G1	220	BC North- C1 Face	127.6	0.061	0.05
87-10-20	G2	220	BC North- C1 Exhaust	102.4	0.075	0.07
87-10-21	G2	220	BC North- C1 Exhaust	146.9	0.100	0.07
87-10-21	G2	220	BC North- C1 Exhaust	199.7	N/A	-
87-10-21	G2	220	BC North- C1 Exhaust	77.7	N/A	-
87-10-22	G2	220	BC North- C1 Exhaust	62.4	N/A	-
86-08-05	H1	220	A3 South Ramp	5.2	0.004	0.08
86-10-29	H1	220	A3 South Sill Entrance	16.3	0.013	0.08
87-10-17	H1	220	A3 South Sill Entrance	41.0	0.184	0.45
87-10-18	H1	220	A3 South Sill Entrance	19.4	0.040	0.21
87-10-19	H1	220	A3 South Sill Entrance	13.1	0.033	0.25
87-10-20	H1	220	A3 South Sill Entrance	17.1	0.026	0.15
87-10-21	H1	220	A3 South Sill Entrance	17.4	N/A	-
87-10-22	H1	220	A3 South Sill Entrance	14.8	N/A	-
86-08-05	H2	220	A3 North Return Air	48.3	0.114	0.24
86-08-06	H2	220	A3 North Return Air	66.8	0.168	0.25
86-08-07	H2	220	A3 North Return Air	22.9	0.079	0.35
86-10-29	H2	220	A3 North Return Air	52.3	0.121	0.23
87-10-17	H2	220	A3 North Return Air	85.6	N/A	-
87-10-18	H2	220	A3 North Return Air	74.6	0.193	0.26
87-10-19	H2	220	A3 North Return Air	63.9	0.172	0.27
87-10-20	H2	220	A3 North Return Air	74.3	0.210	0.28
87-10-21	H2	220	A3 North Return Air	71.5	N/A	-
87-10-22	H2	220	A3 North Return Air	77.1	N/A	-

NOTE: See Table 3.2 for uncertainty associated with radon and radon daughter concentrations attributable to counting statistics.

4.2 Data Trends and Variability

4.2.1 Trends

The data collected during the three field campaigns showed a net increase in radon concentration as the air streams travelled from the fresh air raise, through the various sections of the mine, until eventually leaving the mine through the return air raise.

Fresh air was introduced into the mine at the 220 and 170 Levels, via the FAR, a radon concentration generally less than 0.5 pCi/L (Sites 22 and 22.5). On the 220 Level the fresh air stream travelled through the Mainway until it reached the area of the 835 Crosscut, where during the 1986 campaigns the fresh air stream was ducted to the working faces in the B,C North, B,C South and B,C Centre areas. The return air from the latter two areas was directed via the 835 Crosscut (Site 835) back to the Mainway and hence to the RAR and the surface (Sites 3 and 19).

In the 1987 campaign the Mainway fans and ducting were removed and the flow of air in the 835 Crosscut was reversed to allow fresh air from the Mainway (Site B1) to travel to the eastern end of the Crosscut (Site B2) where it was proportionally split between the B,C Centre and B,C North work areas. Ventilation doors equipped with fans and ducting controlled and directed the flow of fresh air to each work face. Return air from the various work faces was directed to the B,C Sill which acted as a plenum to direct the air to the RAR and the surface (Sites 6, 7 and 19).

Table 4.3, which summarizes the radon concentrations measured at the reference points noted above, shows the trend of increasing radon concentration with distance travelled within the underground workings.

Table 4.3

**AVERAGE RADON CONCENTRATION WITH
INCREASING DISTANCE TRAVELLED UNDERGROUND**

<u>Sample Site #</u>	<u>Sample Location</u>	<u>Radon Concentration¹ pCi/L</u>		
		<u>Min</u>	<u>Max</u>	<u>Number of Samples</u>
22	Decline at 170/220 split	0.3	0.3	2
22.5	Mainway by Fresh Air Raise	-	-	1
A1	Mainway at A3 Access	1.3	10.2	10
A1.5	Mainway outside lunch room	4.1	5.1	3
A2	Mainway at 835 Crosscut	6.4	11.1	5
B1	835 Crosscut at Mainway	8.4	10.7	5
B2	835 Crosscut at B,C split	8.3	12.2	6
C1	B,C Centre - work faces	46.6	130.7	6
C2	B,C Centre - exhaust	62.8	189.1	4
F1	B,C Centre - C North face	47.0	177.7	4
F2	B,C Centre - C North exhaust	60.3	260.0	4
G1	B,C North - C1 face	95.4	127.6	4
G2	B,C North - C1 exhaust	62.4	199.7	5
7	B,C Sill return air at Sill exit	119.8	149.1	5
19	Mine exhaust air at surface	45.2	166.5	7
		92.6	166.5	5 (1987 only)

Note:

- ¹ The results for 17 October 1987 have not been included in this Table because of unusually high readings due to B South breakthrough into Mainway.

4.2.2 Variability in Radon Concentrations

During the August 1986 visit, several variations in radon levels were observed (e.g. 835 Crosscut, 900 C mill hole). To address this observation several sites were selected in the mine to monitor the variability of radon concentrations between test days and test periods. As noted previously in Section 4.1, Site #4 was found to exhibit large variations in the eleven radon measurements made at the site. A similar variability was also observed at Site #19 (the mine exhaust at surface). Variations at Site #4 were attributable to ore handling activities, quantity and quality of ore in the 170 Level mill holes, and variable use of ventilation fans at the various mill holes. The reasons for the variation in radon levels at the #19 site could not be as easily defined.

4.3 Radon Flux Rates

4.3.1 Basis for Analysis

As stated in the request for proposal, in order to avoid the uncertainties inherent in localized flux measurements made on small surfaces, radon flux rates were determined through measurement of incremental changes in concentration of radon between the incoming and outgoing air of selected locations. The locations were selected throughout the mine in both ore and sterile rock. It was the original intent to make the measurement on a routine basis however this was not possible and as a result the analysis is based on data collected through the campaigns.

During the initial two campaigns radon measurements were made throughout the underground workings to establish general trends and to gather data useful in the design of a monitoring program. The third field campaign (nearly a year after the first) was

specifically designed to gather radon flux data, and to this end concentrated on eight specific sections of the mine. These radon flux sections were denoted by the letters A through H (as shown on Figure 4.1).

4.3.2 Data Interpretation

In simple terms the influx of radon into the mine atmosphere was calculated by measuring the incremental change in concentration of radon entering and exiting a specific section of the mine. The net increase in radon concentration was attributed to the influx of radon within that mine section. This net influx was then converted to a nominal unit area flux by dividing the radon influx by the estimated surface area of the section.

It should be noted that the release of radon into the mine atmosphere is dependent on many factors including surface area of exposed rock, effective porosity and moisture content of the rock, ore grade and mineralogy. In addition to the radon released directly from the rock walls within a section of the mine, there may be many other sources of radon contributing to the total amount present. These other sources include mining related sources such as spillage of muck, mucking activities and blasting, in addition to radon from incoming minewater.

With respect to naturally occurring minewater, the Cluff Lake mine is relatively dry. During the three sampling campaigns no large volumes of groundwater were observed entering the mine. Water is used extensively throughout the mine as a coolant and dust suppressant during drilling operations. Small sumps are scattered throughout the mine to serve as collection points from which the water can be pumped to the main mine sump on the 170 Level.

4.3.3 Flux Section Results

Table 4.4 presents a summary of radon data collected in the eight flux sections of the mine (i.e. Sections A to H referred to in Section 4.3.1).

Section A pertains to the portion of Mainway tunnel from the A3 South ramp area to the 835 Crosscut. This 197 m section of the Mainway was driven through sterile rock and for the purpose of this report represents a Ster.1 rock type (see Section 4.3.5 for explanation of various rock types).

During the August and October 1986 campaigns smaller sections of this portion of the Mainway, ranging in length from 20 m to 168 m, were tested. For the eleven sets of results seven showed a net increase in radon levels from inlet to outlet. The calculated (effective, nominal) flux rates for these results ranged from a low of $8.8 \text{ pCi/m}^2\text{.sec}$ to a high of $39.1 \text{ pCi/m}^2\text{.sec}$, with an overall average of $25 \text{ pCi/m}^2\text{.sec}$. General mining activity was on-going during the sample periods.

Section B was the portion of the 835 Crosscut from the Mainway to the split leading into the B,C North and B,C Centre workings. During the October 1987 campaign this 58 m section of the 835 Crosscut was used to deliver fresh air to the B,C Centre and North workings. For the six sets of results four showed a net increase in radon levels from inlet to outlet. The calculated flux rates for these results ranged from a low of $35 \text{ pCi/m}^2\text{.sec}$ on 21 October to a high of $82.5 \text{ pCi/m}^2\text{.sec}$ on 20 October, with an overall average for the four results of $56 \text{ pCi/m}^2\text{.sec}$. General mining activity was on-going during the sample periods.

Section C represents a "C" ore seam work stope within the B,C Centre area of the mine. This stope was divided into two links

CX to CY and CX to CZ, where CX was the common point between the two links and was located at the 790 mill hole (i.e. CY-----CX-----CZ). During the period of 17 to 19 October, measurements were made over the entire section of stope from CY to CZ; however, airflow measurements within the two individual links indicated a substantial airflow in the CX, CY link, and very little airflow in link CX, CZ. As a result on 20 October the field team decided to subdivide the entire stope into two separate radon flux sections, with C representing the link from CX to CY, and F representing the link from CX to CZ. All three radon data results for the revised C section sets showed a net increase in radon levels from inlet to outlet. The calculated radon flux rates ranged from a low of $134.3 \text{ pCi/m}^2\text{.sec}$ to a high of $179.5 \text{ pCi/m}^2\text{.sec}$, with an average for the three rates of $152 \text{ pCi/m}^2\text{.sec}$. During the three sampling periods drilling, rock bolting and mucking operations were in progress.

Only two of the four radon data sets for Section F showed a net increase in radon levels between the inlet and outlet for two of the four sets. This was likely due to the fact that ventilation air flowrates were very low at the time of the measurements (0.2 to $0.8 \text{ m}^3/\text{s}$). The two calculated radon flux rates were 17.3 and $72.9 \text{ pCi/m}^2\text{.sec}$. No mining activities were underway in the F section during the four sampling periods.

Section D represents a "B" ore seam work stope within the B, C Centre area of the mine. One of the two radon data sets showed a net increase in radon concentrations and the calculated radon flux rate for this set was $334 \text{ pCi/m}^2\text{.sec}$. Unfortunately ventilation and access to this area were restricted during the period of 18 to 20 October making it difficult to collect more than two sets of radon samples.

Section E represents a worked out stope within the B,C North area

of the mine. On 17 October the outlet radon concentration indicated a test area with significant potential; however, after one day of sampling the ventilation system to the area was shutdown and the stope closed to unauthorized personnel. No useful radon flux data were obtained for this section.

Section G represents an actively mined "C" ore seam stope within the B,C North area of the mine. Three of the five radon sets indicated a net increase in radon levels between the inlet and the outlet. Flux rates ranged from a low of $57.9 \text{ pCi/m}^2\text{.sec}$ to a high of $775.9 \text{ pCi/m}^2\text{.sec}$, with an overall average of $414 \text{ pCi/m}^2\text{.sec}$. It should be noted that the highest flux rate for this section was calculated using the radon concentration measured in the exhaust air from a very recent blast (sample collected within 5 minutes of the explosion).

Section H represents a worked out "A" ore seam stope currently used as a ventilation sill for exhausting the air from the A3 South workings to the Mainway at the 873 Crosscut. Inlet and outlet radon measurements for this section were made during all three field campaigns, and all data sets showed a net increase in radon levels. Calculated radon flux rates ranged from a low of $43 \text{ pCi/m}^2\text{.sec}$ on 7 August 1986 to a high of $154 \text{ pCi/m}^2\text{.sec}$ on 29 October 1986, with an overall average for the ten samples of $99 \text{ pCi/m}^2\text{.sec}$.

4.3.4 Supplemental Data Results

As noted in the previous section, eight sections of the mine were sampled on a systematic routine basis to determine radon flux rates. To supplement these data radon concentrations measured at other underground locations were reviewed to extract additional data that could be used for similar calculations. Table 4.5 presents the calculated radon flux determinations based on the

TABLE 4.4 : RADON FLUX DETERMINATIONS BASED ON EIGHT FLUX SECTIONS (A to H)

SECTION	ROCK TYPE (1)	CMGWN #	DATE	RADON (pCi/L)			LENG. PERIM.		SURF AREA (m ²)	X-SECT. FLOW (2)		FLOWRATE (m ³ /s)	RADON FLUX (pCi/m ² .sec)
				START	END	dRn	(m)	(m)		AREA (m ²)	FLOW (m/s)		
A	Ster.1	1	AUG.5	3.3	5.1	1.8	110	17.6	1939			36.8	34.2
		1	AUG.6	3.5	4.8	1.3	168	17.6	2962			36.8	16.2
		1	AUG.7	1.3	1.6	0.3	20	17.6	352			36.8	31.4
		2	OCT.29	1.6	4.1	2.5	168	17.6	2962			36.8	31.1
		3	OCT.16	2.4 *	4.7	2.3	197	17.6	3473	1.68 *	18.6	34.0	22.5
		3	OCT.17	36.5	35.3	-1.2	197	17.6	3473	1.68 *	18.6	34.0	-11.7
		3	OCT.18	10.2	11.1	0.9	197	17.6	3473	1.68 *	18.6	34.0	8.8
		3	OCT.19	8.1	6.4	-1.7	197	17.6	3473	1.77	18.6	32.9	-16.1
		3	OCT.20	5.4	7.1	1.7	197	17.6	3473	1.60	18.6	29.8	14.6
		3	OCT.21	5.8	10.7	4.9	197	17.6	3473	1.49	18.6	27.7	39.1
		3	OCT.22	7.9	6.5	-1.4	197	17.6	3473	1.85	18.6	34.4	-13.9
B	Ster.2	3	OCT.17		32.4								
		3	OCT.18	9.8	11.2	1.4	58	15.8	914	1.69 *	15.5	26.1 *	40.0
		3	OCT.18	9.8	12.1	2.3	58	15.8	914	1.69 *	15.5	26.1 *	65.7
		3	OCT.19	9.2	8.3	-0.9	58	15.8	914	1.58	15.5	24.5	-24.1
		3	OCT.20	9.1	12.2	3.1	58	15.8	914	1.57	15.5	24.3	82.5
		3	OCT.21	10.7	11.9	1.2	58	15.8	914	1.72	15.5	26.6	35.0
		3	OCT.22	8.4	8.3	-0.1	58	15.8	914	1.87	15.5	28.9	-3.2
C	Ore.1 (Links CX, CE & CX, CY) (Link CX, CY)	3	OCT.17	61.4 *	214.3	152.9	69	11.2	770	0.24 *	7.2	1.7 *	344.9
		3	OCT.18	66.7	189.1	122.4	69	11.2	770	0.24 *	7.2	1.7 *	276.1
		3	OCT.19	56.0									
		3	OCT.20	130.7			27	11.2	307	0.48	7.2	3.5	
		3	OCT.21	46.6	61.0	14.4	27	11.2	307	0.42	7.2	3.0	142.8
		3	OCT.21	60.4	78.5	18.1	27	11.2	307	0.42	7.2	3.0	179.5
		3	OCT.22	47.0	62.8	15.8	27	11.2	307	0.36	7.2	2.6	134.3
D	Ore.1	3	OCT.17		110.8								
		3	OCT.21	39.9	92.7	52.8	86	8.8	758	1.06	4.5	4.8	334.6
		3	OCT.22	102.1	79.5	-22.6	86	8.8	758	0.48	4.5	2.1	-63.7
E	Ore.2	3	OCT.17		604.7								
		3	OCT.18	63.8	62.6	-1.2	35	8.9	307	0.41	4.5	1.8	-7.1
F	Ore.2 (Link CX, CE)	3	OCT.20	66.2	76.3	10.1	41	11.2	465	0.11	7.2	0.8	17.3
		3	OCT.21	104.0	260.0	156.0	41	11.2	465	0.03	7.2	0.2	72.9
		3	OCT.21	177.7	112.0	-65.7	41	11.2	465	0.03 *	7.2	0.2 *	-30.7
		3	OCT.22	83.8	60.3	-23.5	41	11.2	465	0.05	7.2	0.4	-18.3
G	Ore.1	3	OCT.20	95.4	102.4	7.0	28	10.4	291	0.36	6.7	2.4	57.9
		3	OCT.21	109.2	146.9	37.7	28	10.4	291	0.47	6.7	3.1	407.3
		3	OCT.21	114.6	77.7	-36.9	28	10.4	291	0.40 *	6.7	2.7 *	-336.4
		3	OCT.21	114.6 *	199.7	85.1	28	10.4	291	0.40 *	6.7	2.7 *	775.9
		3	OCT.22	127.6	62.4	-65.2	28	10.4	291	0.36	6.7	2.4	-539.5
H	Ore.2	1	AUG.5	5.2	48.3	43.1	278	11.9	3305	0.90	8.8	7.9	103.6
		1	AUG.6	5 *	66.8	61.8	278	11.9	3305	0.90	8.8	7.9	148.6
		1	AUG.7	5 *	22.9	17.9	278	11.9	3305	0.90	8.8	7.9	43.0
		2	OCT.29	16.3	52.3	36.0	278	11.9	3305	1.60	8.8	14.1	153.9
		3	OCT.17	41.0	85.6	44.6	278	11.9	3305	0.63 *	8.8	5.5 *	74.8
		3	OCT.18	19.4	74.6	55.2	278	11.9	3305	0.63 *	8.8	5.5 *	92.5
		3	OCT.19	13.1	63.9	50.8	278	11.9	3305	0.64	8.8	5.7	86.9
		3	OCT.20	17.1	74.3	57.2	278	11.9	3305	0.63	8.8	5.6	96.3
		3	OCT.21	17.4	71.5	54.1	278	11.9	3305	0.64	8.8	5.7	92.5
		3	OCT.22	14.8	77.1	62.3	278	11.9	3305	0.60	8.8	5.3	99.9

NOTE: * Denotes estimated value 1. See Section 4.3.5 for rock types. 2. Average of field team flow measurements.

TABLE 4.5 : RADON FLUX DETERMINATIONS BASED ON SUPPLEMENTAL DATA

DATE	SITE #		ROCK TYPE (1)	RADON (pCi/L)			LENGTH (m)	PERIMETER (m)	SURFACE		RADON FLUX (pCi/m ² .sec)
	START	END		START	END	dRn			AREA (m ²)	FLOWRATE (m ³ /s)	
AUG. 6	22	21.5	Ster.1	0.3	1.5	1.2	540 *	19.6	10584	23.5	2.7
	21.5	21	Ster.1	1.5	3.8	2.3	510 *	16.0	8160	24.5	6.9
	835	835	Ore.2	59.9	104.4	44.5	47	15.8	736	16	967.0
	A1.5	BS	Ore.1	4.8	42.3	37.5	5 *	12.6	63	6.1	3631.0
	A1.5	CS	Ore.1	4.8	58.7	53.9	5 *	14.2	71	8.5	6452.8
	BS	835	Ore.2	42.3	59.9	17.6	80 *	12.6	1008	6.1	106.5
	CS	835	Ore.2	58.7	59.9	1.2	66 *	14.2	937	8.5	10.9
AUG. 7	835	835	Ster.3	115.9	177.1	61.2	10	15.8	158	16	6217.1
	835	835	Ster.3	177.1	267.7	90.6	10	15.8	158	16	9203.8
	835	835	Ster.3	267.7	212.8	-54.9	10	15.8	158	16	-5577.1
	835	835	Ster.3	212.8	242.1	29.3	10	15.8	158	16	2976.5
	835	835	Ster.3	242.1	174.6	-67.5	10	15.8	158	16	-6857.1
	835	835	Ster.3	174.6	205.6	31.0	10	15.8	158	16	3149.2
	835	835	Ster.3	115.9	267.7	151.8	20	15.8	315	16	7710.5
	835	835	Ster.3	115.9	212.8	96.9	30	15.8	473	16	3281.3
	835	835	Ster.3	115.9	242.1	126.2	40	15.8	630	16	3205.1
	835	835	Ster.3	115.9	174.6	58.7	50	15.8	788	16	1192.6
	835	835	Ster.3	115.9	205.6	89.7	60	15.8	945	16	1518.7
	20.5	746	Ster.4	1.1	10.9	9.8	76	15	1140	3.4	29.2
	20.5	746	Ster.4	1.1	14.4	13.3	47	15	705	5.5	103.8
OCT. 29	835	835	Ster.3	80.2	72.4	-7.8	10	15.8	158	22.5	-1114.3
	835	835	Ster.3	72.4	68.4	-4	10	15.8	158	22.5	-571.4
	835	835	Ster.3	68.4	72.8	4.4	10	15.8	158	22.5	628.6
	835	835	Ster.3	79.7	75	-4.7	10	15.8	158	22.5	-671.4
	835	835	Ster.3	75	74.7	-0.3	10	15.8	158	22.5	-42.9
	835	835	Ster.3	74.7	77.1	2.4	10	15.8	158	22.5	342.9
OCT. 30	A1.5	BS	Ore.1	5 *	49.1	44.1	5 *	12.6	63	20 *	14000.0
	BS	BS	Ore.1	49.1	58.3	9.2	158 *	12.6	1991	20 *	92.4
	BS	BS	Ore.1	58.3	70.4	12.1	42 *	12.6	529	20 *	457.3
	170	170	Ster.4	2.2	3.9	1.7	37 *	18.6	688	29.7	73.4
	170	170	Ster.4	2.2	3.5	1.3	37 *	18.6	688	29.7	56.1
OCT. 17	82	10	Ore.1	32.4	35.1	2.7	20 *	15.8	316	9.1	77.8
	82	11	Ore.1	32.4	51.3	18.9	25 *	15.8	395	19.6	937.8
OCT. 21	22	21	Ster.1	0.3 *	3.2	2.9	1050	17.8	18690	21 *	3.3
OCT. 22	22	21	Ster.1	0.3	3.9	3.6	1050	17.8	18690	21 *	4.0

NOTES: * Denotes Estimated Value

1. See Section 4.3.5 for description of rock types.

supplemental data. The flux rates presented on Table 4.5 represent a variety of locations in the mine including the Decline from the 220 Level to surface, 10 metre sections of the 835 Crosscut, a section on the 170 Level, and stopes in the B South and C South areas of the mine. Flux rates range from a low of 2.7 pCi/m².sec for the Decline to the highest measured anywhere in the mine at 14,000 pCi/m².sec for a 5 m section in the B South workings.

With respect to the Decline, measurements were made on 6 August 1986 and 21, 22 October 1987. All four results showed a net increase in radon levels up the Decline with consistent calculated flux rates between the two field campaigns (e.g. 2.7, 6.9, 3.3, 4.0 pCi/m².sec).

Results for the 835 Crosscut 10 metre sections showed considerable variability, both between sample periods and sample points (e.g. 7 August and 29 October results). It should be noted that during the 7 August sampling the upstream mining activities were in operation. The 29 October sampling was conducted while the mining activities were temporarily suspended for the changeover between the day shift and the evening shift.

4.3.5 Compilation of Flux Rates by Rock Type

Table 4.6 presents a compilation of radon flux data by rock type. The six rock types by which the data have been grouped are as follows:

- Ster.1 - workings driven through sterile rock, used as travelway in the mine and for fresh air delivery
- Ster.2 - workings through sterile or very low grade ore rock, with potential radon influx from narrow ore

Table 4.6

COMPILATION OF RADON FLUX RESULTS BY ROCK TYPE¹

<u>Rock Type</u>	<u>Number of Results</u>	<u>Radon Flux Rate (pCi/m².sec)</u>		
		<u>Average</u>	<u>Minimum</u>	<u>Maximum</u>
Ster.1	12	18	3	39
Ster.2	4	56	35	83
Ster.3	11	3584	343	9204
Ster.4	4	66	29	104
Ore.1	16	1769	58	14000
	13 (2)	325	58	938
Ore.2	15	144	11	967

Note:

- 1 Data used in the preparation of this table are presented on Appendix Table A.4.
- 2 Three flux sections of 5 m length not included.

seams that intersect the stope, used as travelway and for fresh air delivery

- Ster.3 - workings through sterile or very low grade ore rock, with potential radon influx from narrow ore seams that intersect the stope or Mainway, used as travelway in the mine and for exhaust air return
- Ster.4 - workings through sterile rock with potential influx from ore in mill holes, (applicable only to 170 Level) used for access to mill holes and fresh air delivery
- Ore.1 - workings through ore, actively being mined, used as exhaust air return
- Ore.2 - formerly workings through ore, now mined out area of underground working used as exhaust air return

Of the four types of sterile rock sections measured, calculated flux rates for Ster.1 rock type were the lowest. The rates ranged from a low of $2.7 \text{ pCi/m}^2\text{.sec}$ to a high of 39.1, with an overall average of $18 \text{ pCi/m}^2\text{.sec}$ for the 12 Ster.1 results. The average flux rates for the Ster.2 and Ster.4 rock types were 56 and $66 \text{ pCi/m}^2\text{.sec}$, approximately three times higher than the rate for the Ster.1 rock type.

Results for the Ster.3 rock type show a considerable spread in the data between the minimum and maximum flux rates. A review of the data for Ster.2 and Ster.3 (which both represent the 835 Crosscut) and the configuration of the Crosscut during the measurements (fresh air delivery vs exhaust air return) suggests that the spread in flux rates for the Ster.3 rock type is more likely due to variations in upstream radon concentrations

resulting from the various mining activities than to influx of radon from the walls of the 835-Crosscut. It should be noted that the timespan between the inlet and outlet samples over which the August 1986 Ster.3 measurements were made was some 40 minutes.

The average flux rate for the sixteen Ore.1 data sets was 1769 pCi/m².sec, nearly 100 times higher than the average rate for the Ster.1 rock type. However, this average is reduced to 325 pCi/m².sec when the results for the three 5 metre long flux sections are not included.

The average flux rate for the fifteen Ore.2 data sets was 144 pCi/m².sec, eight times greater than the average rate for the Ster.1 rock type.

4.4 Radon Flux Rate for Entire Mine

One of the "tasks to be performed" as outlined in the original request for proposal was the measurement of the total outflow of radon from the whole mine from concentration and air flow measurements at the air exhaust shafts, and estimation of the total surface area of the mine openings, to calculate the average radon flux per unit surface area for the whole mine.

To address this request measurements were made during the October 1986 and October 1987 field visits, of radon concentrations in the return air raise at surface, and at the entrance/exist portal to the mine. Approximate air flow rates at these two exhaust points were known by the Cluff Lake radiation protection personnel based on monthly ventilation survey results.

With respect to total surface area of mine openings, Table 4.7 presents a summary of the estimated 1986 and 1987 surface areas

TABLE 4.7 -SURFACE AREA FOR THREE MAJOR COMPONENTS OF MINE

MAJOR COMPONENT	SUB-COMPONENT	ROCK TYPE	LENGTH (m)	PERIMETER (m)	SURFACE AREA (m ²)	CAMPAIGN AREA (m ²)	
						1986	1987
220 LEVEL	Mainway from decline to A3	Ster.1	220	17.6	3872	3872	3872
	Mainway from A3 to 835	Ster.1	197	17.6	3467	3467	3467
	Mainway from 835 to RAR	Ster.1	110	17.6	1936	1936	1936
	835 Crosscut	Ster.2	68	15.8	1074	-	1074
	835 Crosscut	Ster.3	68	15.8	1074	1074	-
	B and B2 South Workings	Ore.1	200	12.6	2520	2520	-
	C South Workings (closed off, no ventilation)					-	-
	B,C North Workings	Ore.1	50	15	750	750	-
	A3 Sill	Ore.2	278	11.9	3308	3308	3308
	A3 South Ramp Workings	Ore.2	75	11.9	893	893	893
	Mill Holes -eleven	Ster.2	550	3.1	1705	1705	-
	Mill Holes -fifteen	Ster.2	750	3.1	2325	-	2325
	B,C Ventilation Sill	Ore.2	310	10	3100	-	3100
	B,C South Workings	Ore.1	270	12.6	3402	-	3402
	B,C Centre Workings	Ore.1	255	12.6	3213	-	3213
	B,C North Workings	Ore.1	180	15	2700	-	2700
					SUBTOTAL	19525	29290
170 LEVEL	October 1986 Configuration	Ster.2	735	18	13230	13230	13230
	Link to 746 Crosscut	Ster.2	125	15	1875	-	1875
					SUBTOTAL	13230	15105
DECLINE	170 Level to Portal	Ster.1	1150	17.8	20470	20470	20470
					SUBTOTAL	20470	20470
TOTAL FOR ENTIRE MINE						53225	64865

TABLE 4.8 : RADON FLUX DETERMINATIONS FOR 170 LEVEL, DECLINE AND ENTIRE MINE

COMPONENT	DATE	SITE #		RADON (pCi/L)			SURFACE AREA (m ²)	FLOW- RATE (m ³ /s)	RADON FLUX (pCi/m ² .sec)
		START	END	START	END	dRn			
170 LEVEL	AUG.6	20.5	4	0.1 *	21.3	21.2	13230	8.4	13.5
	AUG.7	20.5	4	0.1 *	44.8	44.7	13230	8.4	28.4
	OCT.29	20.5	4	0.1 *	19.2	19.1	13230	22.9	33.1
	OCT.30	20.5	4	0.1 *	29.8	29.7	13230	22.9	51.4
	OCT.16	20.5	4	0.1 *	363.3	363.2	15105	17.2	413.6
	OCT.17	20.5	4	0.1 *	43.5	43.4	15105	17.2	49.4
	OCT.18	20.5	4	0.1 *	37.7	37.6	15105	17.2	42.8
	OCT.19	20.5	4	0.1 *	101.9	101.8	15105	17.2	115.9
	OCT.20	20.5	4	0.1 *	83.6	83.5	15105	17.2	95.1
	OCT.21	20.5	4	0.1 *	56.9	56.8	15105	17.2	64.7
	OCT.22	20.5	4	0.1 *	59.6	59.5	15105	17.2	67.8
	PRORATED AVERAGE					54.6		16.2	61.5
ENTIRE MINE (170 + 220)	OCT.29	22.5	19	0.1 *	45.2	45.1	32755	75.1	103.4
	OCT.30	22.5	19	0.1 *	46.7	46.6	32755	75.1	106.8
	OCT.18	22.5	19	0.1 *	107	106.9	44395	59.4	143.0
	OCT.19	22.5	19	0.1 *	95	94.9	44395	59.4	127.0
	OCT.21	22.5	19	0.1 *	166.5	166.4	44395	59.4	222.6
	OCT.22	22.5	19	0.1 *	110.7	110.6	44395	59.4	148.0
	PRORATED AVERAGE					82.8		67.3	132.6
DECLINE TO SURFACE	AUG.6	170	21	0.1 *	3.8	3.7	20470	24.5	4.4
	OCT.30	170	21	0.1 *	2.4	2.3	20470	24.9	2.8
	OCT.21	170	21	0.1 *	3.2	3.1	20470	21.2	3.2
	OCT.22	170	21	0.1 *	3.9	3.8	20470	21.2	3.9
	PRORATED AVERAGE					3.2		23.5	3.6

NOTES: * Denotes estimated quantity.

for the 220 and 170 Levels, and the Decline. The estimated total surface area for the October 1986 mine configuration was approximately 53,000 m² and was increased to nearly 65,000 m² for the October 1987 configuration.

With respect to whole mine radon flux rates, Table 4.8 presents the calculated rates and prorated averages for the 170 Level, the Decline, and the entire mine. Because of the configuration of the ventilation network on the 220 Level, interaction between the 170 and 220 Levels, and the variation of flow rates throughout the network it was not possible to estimate a separate rate for the 220 Level. The calculations for the entire mine were based on the 170 and 220 Level workings that were vented to surface through the return air raise. The flux rates for the entire mine range from a low of about 100 pCi/m².sec to a high of about 220 pCi/m².sec, with a prorated average for the two field campaigns of about 130 pCi/m².sec.

To calculate the average radon emission rate from the whole mine (170, 220 Levels plus Decline), the prorated increases in radon concentrations were multiplied by the prorated airflow rates for the Decline and entire mine, and the two products were summed. The resulting total yielded an average radon emission rate of 5.6×10^6 pCi/sec. These emissions are vented to atmosphere via the portal and the return air raise. Approximately 99% of these emissions are released via the RAR.

5.0 VENTRAD MODEL IMPLEMENTATION AND VALIDATION

5.1 Model Background

In 1984, the Atomic Energy Control Board of Canada (AECB) sponsored a study to develop a practical computer model for the calculation of ventilation parameters applicable to underground uranium mine environments. The study identified a model developed at Queen's University under the guidance of Dr. K. Notley as incorporating most of the features desired by the AECB. The model used, described in detail in the study findings (SENES, 1984), describes the mine environment in two stages.

The first stage is a mine ventilation program which balances flows in the mine using the Hardy Cross method, while the second stage determines the radon daughter levels.

5.2 VENTRAD Implementation

The Queen's University model, VENTRAD was originally designed to operate on a mainframe computer. Mainframe computer time is both expensive and hard to obtain, therefore, SENES downloaded the model to allow operation on DOS based machines such as the IBM AT. Once downloaded the model could be run a multitude of times for the cost of one mainframe run and the downloaded program could be run at the mine location. By running the model on-site, changes to the mine and the ventilation patterns could be input immediately.

In order to operate the VENTRAD program on a DOS machine, a minimum hardware configuration (listed below), is required. This minimum configuration reflects the complex nature of the model.

Minimum Hardware Configuration

- 1) hard disk drive
- 2) math coprocessor
- 3) DOS 3.0 or greater

5.3 Mine Configuration

The VENTRAD program requires that a mine network be developed. A network is a mathematical representation of a real-world mine ventilation system. It is an assembly of data associated with the airways in the mine ventilation system. The airways in the system are called branches. The branches are interconnected at points called nodes. Each branch is represented by an initial node and a final node. Airflow direction is defined as positive if it goes from the initial to the final node and negative for the other case. Nodes are placed where the mine airway changes size, at the connection of three or more airways, or where the characteristics of the airway changes in some other way. The addition of nodes can facilitate the modeling of airways with greatly fluctuating radon emanation rates. The networks used to represent the 220 and 170 Levels of the mine are given in Figures 5.1 to 5.2.

5.3.1 Ventilation Program

In order to run the ventilation program two input files had to be created for the fan characteristic curves and the branch input file. To set up the branch input file a mine ventilation network, that is, a mathematical representation of the real Cluff Lake mine ventilation system had to be established.

A mine ventilation network is essentially a collection of airways or branches and data associated with them. Each branch has two

FIGURE 5.1
220 LEVEL VENTILATION NETWORK

LEGEND:

- CONDUIT BRANCH
- REGULAR BRANCH
-  VENTILATION FAN INDICATING DIRECTION OF FLOW
-  NODE IDENTIFIER
(Is NODE 2215 ON THE 220 LEVEL)
-  NODE IDENTIFIER FOR A NODE ACCESSED ON THE
OTHER LEVEL (Is NODE 1715 AS SEEN FROM
THE 220 LEVEL)
-  NODE IDENTIFIER FOR AN UNDERCUT NODE
(Is NODE 2015 IS ON UNDERCUT OF THE 220 LEVEL)
-  ATMOSPHERE

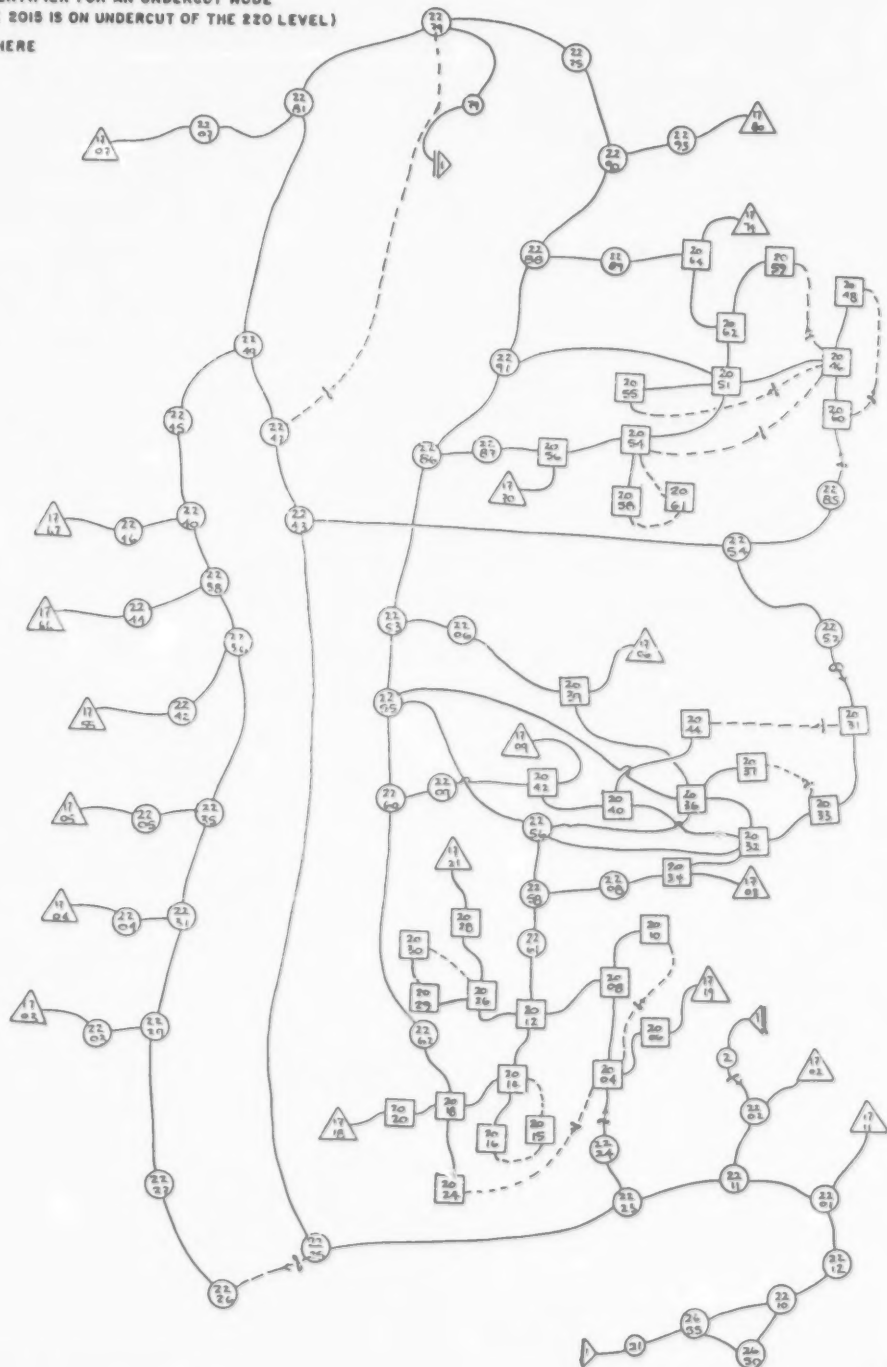
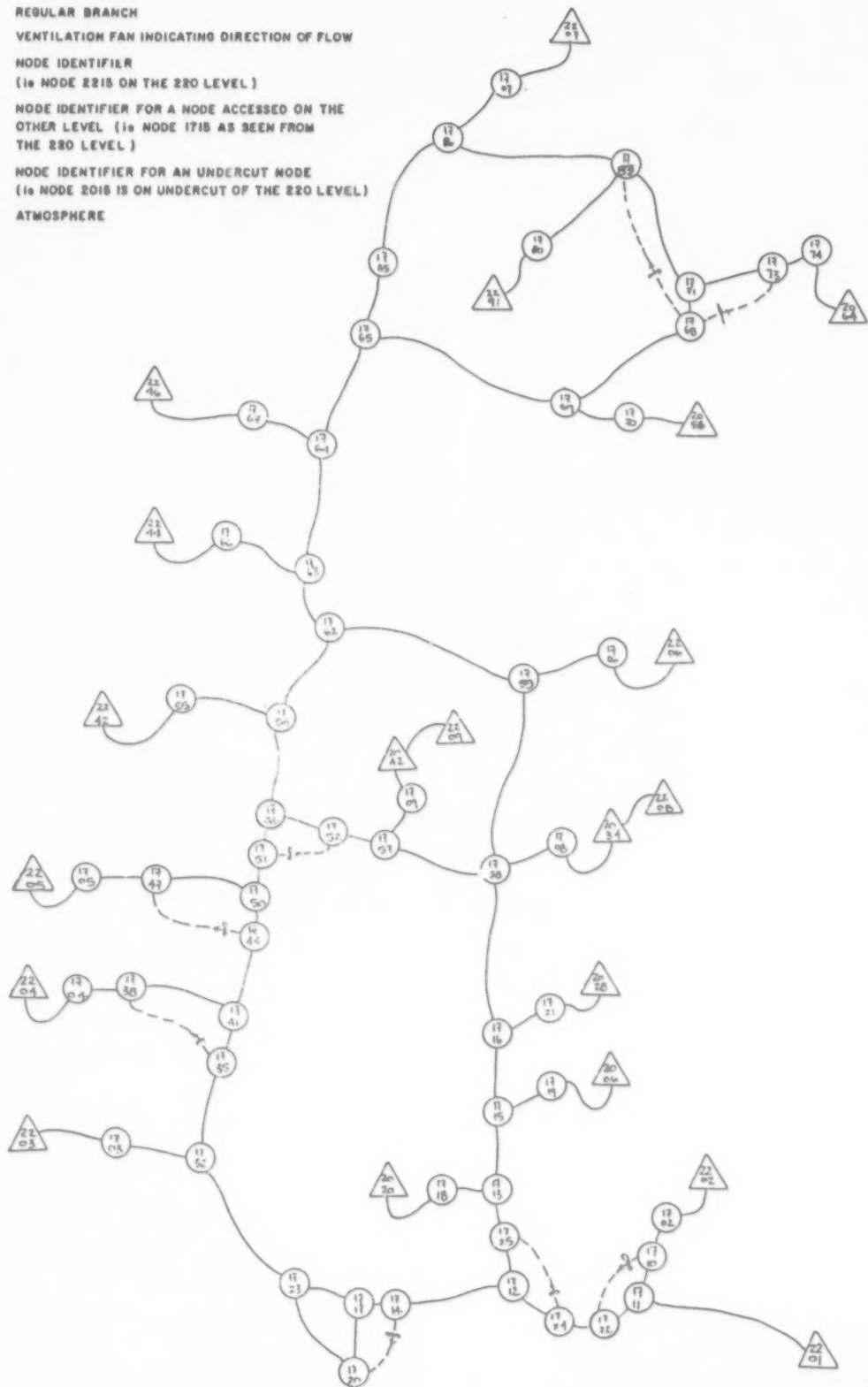


FIGURE 3.2
170 LEVEL VENTILATION NETWORK

LEGEND:

- CONDUIT BRANCH
- REGULAR BRANCH
- ⌞ VENTILATION FAN INDICATING DIRECTION OF FLOW
- ⊙ NODE IDENTIFIER
(i.e. NODE 2215 ON THE 220 LEVEL)
- △ NODE IDENTIFIER FOR A NODE ACCESSED ON THE
OTHER LEVEL (i.e. NODE 1715 AS SEEN FROM
THE 220 LEVEL)
- ⊠ NODE IDENTIFIER FOR AN UNDERCUT NODE
(i.e. NODE 2015 IS ON UNDERCUT OF THE 220 LEVEL)
- ⌞ ATMOSPHERE



endpoints, an initial and a final node. Each node is assigned a unique integer value. The program handles the five different branch types shown below.

Branch Type 1: Normal branch, in which the pressure drop will be calculated as $P = R Q^2$.

Branch Type 2: Regulator branch $P = R Q^2$ with Q always less than or equal to the specified regulator flow.

Branch Type 3: Fan branch. $P = R Q^2 + F(Q)_i$

$F(Q)_i$ - pressure of fan (i) at flow rate Q from fan characteristic curve.

Branch Type 4: Imposed flow (fixed quantity) branch $Q = Q_1$. use for initial run to size fans. Flow in the branch will be maintained at Q_1 .

Branch Type 5: Linear characteristic branch where $P = -R_L Q$ and R_L = linear resistance. Use for flow through caved ground or high resistance doors (Laminar flow).

The branch resistance was determined by using the following equation:

$$R = \frac{KP (L + Le)}{A^3} \quad (5.1)$$

where

- K = empirical friction factor (kg/m^3)
- P = perimeter of branch (m)
- L = length of branch (m)
- L_e = equivalent length accounting for shock factors associated with branch (m)
- A = cross sectional area of duct (m^2)

(see Hartman (1982) for full explanation of resistance calculations).

The empirical friction factors used were from McElroy (1935) and represented the physical situation observed at Cluff Lake.

The next step was to establish the preliminary flow for each branch. Wherever possible, the flows measured by SENES personnel in the field and or those given in the October ventilation survey conducted by Amok were used. Other flows were determined by following Kirchhoff's laws of flow.

If a branch was either a regulator, a fan or imposed flow branch, then additional information had to be supplied. A regulator branch required a maximum allowable flow, a fan branch required the fan characteristic curve number and an imposed flow branch required the specification of the final flow. A fan is represented in the circuit by a plot of fan pressure vs. flow called a fan characteristic curve that is associated with a fan branch. The fan branch also has a normal resistance and an attendant RQ^2 pressure drop. For a specified flow, the program interpolates a fan pressure and slope of the fan curve between the two fan data points bracketing the flow for use in the Hardy Cross method.

The inputs used to represent the mine ventilation patterns of the mine were varied using an iterative process. Those branches for which flows were measured either by Amok personnel or by SENES, were used as tests of the models validity. Changes were made to those branches for which uncertainties existed about actual roughness until suitable agreement was achieved for the test branches.

5.3.2 Radiation Program

The radiation program calculates the radon concentration and working levels in the branches of the network. Two input files are required, a branch file and an emanation file. The branch file is created by the mine ventilation program and includes the initial node, the final node, the balanced flow rate, the branch length and the branch cross sectional area. The emanation file characterizes the radon emanation patterns of the branches in the network. For each branch the emanation rate and surface area from which that rate occurs are specified. Up to five pairs of emanation rates and areas can be specified for each branch. In addition to the surface emanation rates, radon concentrations and working levels can be input for a specific node.

The appropriate emanation characteristics for the branches of the mine network were determined by field observation. Each branch was identified as one of the six rock types listed in Table 4.6. The emanation rates listed were assigned to the branch, and the emanating surface was calculated by multiplying the branch perimeter by the branch length. The validity of the emanation assumptions was tested by comparing the output from the program to those values measured in the field.

5.4 Model Validation

5.4.1 Ventilation Program

As mentioned in Section 5.3, the validation of the ventilation program was carried out in an iterative fashion. With each successive run, the model inputs were changed in an attempt to get agreement between the flows calculated by the model and those values observed in the field. Table 5.1 presents a summary of values measured in the field and used in the validation process.

These changes were performed according to a set hierarchy; those branches inaccessible to SENES field personnel were changed first, then those branches for which observations were made but no flows measured were changed, and finally changes were made to those branches for which flows were measured. The parameters to which changes were applied were also conducted according to a hierarchy; first the surface roughness was changed and then the L_e (equivalent length) was changed to reflect restriction head losses and shock head losses.

In general, close agreement was achieved for those branches unaffected by fan driven flows. Those branches directly downstream of a fan were difficult to get any agreement between the observed field values and the model calculated values. This problem was due to the fact that the fan characteristic curves input into the program reflect the design performance of the fan. If the fan was not being run at full performance, as was often the case, then the program would overestimate the flows in that branch.

Another area where agreement between measured flows and calculated flows was difficult to achieve was near the "mill-holes". The "mill-holes" are used to transfer the mined ore from

Table 5.1

SUMMARY OF MEASURED VENTILATION PROGRAM PARAMETERS

Section		Flow	Flow
Start	End	Estimate (m ³ /s)	Measured (m ³ /s)
1	2	80	80
2225	2226	6	10
2247	2249	0.10	0.10
2247	2279	5.5	2.0
2252	2031	16	9
2031	2044	6	3
2033	2037	3	12
2224	2004	10	8
2004	2010	3.5	10
2285	2060	12	8
2060	2048	3	8
2046	2059	1.5	10
2046	2055	4	8
1710	1722	15	8
1724	1725	3	2
1714	1720	3.5	5
1735	1738	2.5	5
1744	1747	2.5	5
1751	1752	3	1
1768	1773	1	6
1768	1783	3	5

the mining level to the sterile extraction level. When the "mill-holes" were covered, the flow was effectively zero. When the "mill-holes" were open and mucking operations were going on, air was drawn down the holes with the ore.

In order to achieve full agreement between measured flows and the modelled values, it would be necessary to know the complete mine status at the time of measurement. The complete mine status would include information on such item as the condition of all mill-holes (viz-a-viz, whether open, closed, in use, blocked, etc.), the status of ventilation doors and bulkheads, operational status of all ventilation fans and a listing of the actual fan performances. This information would be difficult to get during the mining operations; however, the variability in the mine status and the impact on sample results could be reduced if all measurements were taken when the mine was empty and no mining was being performed. Unfortunately due to safety restrictions, SENES personnel could not conduct measurements between mining shifts.

Input files for the ventilation program pertaining to Branch Network Characteristics and Fan Data are presented in Appendix B.1 and B.2 respectively. The output file from the ventilation program is presented in Appendix B.3.

5.4.2 Radiation Program

The radiation program is dependent upon three sets of input; the flow rates from the mine ventilation program, the emanating surface area, and the emanation rate. The emanation rates used were those listed in Table 4.6. For each branch the rock type was determined and the appropriate emanation rate assigned. The surface area and the flow rate were taken from the ventilation program and as discussed in the previous section, were generally in close agreement with those values measured in the mine.

For those sections of the mine where there was close agreement between the ventilation program and field measurements, there was also close agreement between the radiation program and the measured values. These areas were the A₃ sill area, the Mainways, B, C Centre and B, C North (see Table 5.2 for summary table of results and observed values). In areas where the flows were very low, such as B, C South, there was little agreement between measured values and the program output. In the B, C South area, the residence time for the air is very high and this caused large quantities of radon to be accumulated. This contaminated air was subsequently transported to the 170 Level through the mill holes causing higher than expected values on the 170 Level.

In order to achieve agreement between the model output and the measured values it would be necessary to get the mine ventilation calibrated. As mentioned in the previous section this would require a status report on the entire mine including fans and mill holes.

Input files for the radiation program pertaining to Mine Characteristics and Emanation Characteristics are presented in Appendix B.4 and B.5 respectively. The Output File from the radiation program is presented in Appendix B.6.

Table 5.2

SUMMARY OF PREDICTED AND MEASURED RADON CONCENTRATIONS

<u>Section</u>		<u>Predicted Radon (pCi/L)</u>	<u>Average Measured Radon (pCi/L)</u>	<u># of Readings</u>	<u>Range</u>
2279	79	113	95	7	45 to 167
1717	1720	57	5	6	2 to 11
1723	1732	57	3.6	3	3.4 to 3.9
2655	21	8.4	3.6	2	3.2 to 3.9
2212	2210	6.8	2.2	2	1.5 to 2.9
2202	2211	0.4	0.1	1	- to -
2249	2281	113	66	4	44 to 96
1707	2207	120	50	10	19 to 102
2281	2279	118	65	9	34 to 98
2275	2279	156	182	2	153 to 212
2290	2275	156	134	6	120 to 150
2223	2225	2.0	4.5	10	1 to 10
2225	2243	3.8	6.7	9	4 to 11
2243	2254	6.1	10.6	6	8 to 12
2048	2046	81	118	5	62 to 200
2240	2245	111	64	10	23 to 86
2226	2227	10.8	15	7	5 to 19

6.0 CONCLUSIONS AND RECOMMENDATIONS

The field sampling program designed and conducted by SENES Consultants Limited was successful in determining radon flux rates for various locations in the Cluff Lake Uranium Mine. Radon flux rates ranged from a low of 4 pCi/m².sec for sterile rock to a high of 14,000 pCi/m².sec for an active work face.

The dynamic nature of the mine with respect to the rapid rate of work face development, the method of ore handling (mill holes), the frequency of blasting (anytime during the work shift), and the use of auxiliary ventilation fans and ducting contributed to wide variations from day to day in radon values in certain areas of the mine.

However, when reviewed on an overall mine basis the data collected during the three field campaigns showed a measureable increase in radon concentration as the air stream travelled from the fresh air raise, through the various sections of the mine, until eventually exiting the mine through the return air raise.

The average radon emission rate for the entire mine was estimated to be 5.6×10^6 pCi/second, with approximately 99% of this emission released to the atmosphere via the return air raise. The estimated total surface areas for the October 1986 and 1987 configurations were 53,000 and 65,000 m² respectively. Based on these data the prorated average radon flux rate for the entire mine was 130 pCi/m².second.

The radon and ventilation data collected during the field campaigns were used to validate the VENTRAD computer model. The estimated air flow rates for the branches unaffected by fan driven flows were found to be in close agreement with rates

measured in the field. Those branches directly downstream of auxiliary ventilation fans were difficult to model accurately. Mill holes also presented problems with respect to ventilation modelling.

Because the radiation component of the VENTRAD program is dependent on the output (flow rates) from the ventilation component close agreement between predicted and measured radon levels was obtained for those sections of the mine where there was also close agreement between the ventilation program and field measurements. Radon levels for branches directly downstream of auxiliary ventilation fans and mill holes were difficult to model accurately.

The overall assessment of the VENTRAD model is that it works well as a predictive tool for "steady state" conditions and would be very applicable for the assessment of conceptual mine ventilation designs.

It is recommended for future application of the VENTRAD program that the branch network design be kept as simplistic as possible in terms of overall mine representation. The level of detail modelled in this project for the Cluff Lake facility was too complex.

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APPENDIX A.1

**DATA SPREAD SHEET
FOR AUGUST 1986
FIELD PROGRAM**

RADON MEASUREMENT PROGRAM AT CLIFF LAKE URANIUM MINE

RESULTS OF RADON MONITORING AUGUST 1986

DATE	LOCATION	CELL #	COUNTER	SAMPLE TIME	TIME OF COUNT	NET HOURS	TOTAL COUNTS	COUNT TIME	GROSS CPM	CELL RAD	NET CPM	TIME FACTOR	CELL FACTOR	RADON CONC. (pCi/L)
86-08-05	220 A3 SOUTH RAMP (22-14)	76	1	8.50	12.25	3.67	122	10	12.20	.4	11.40	.973	2.3	5.19
86-08-05	220 835 I-CUT	79	2	8.83	12.25	3.42	1044	10	104.40	.4	104.00	.974	2.3	46.40
86-08-05	220 NORTH END, A3 STILL	80	1	9.00	12.75	3.67	2163	20	108.15	.2	107.95	.974	2.3	46.26
86-08-05	220 C1 SILL, MILLURLE 900 C	81	2	9.25	12.75	3.50	7723	20	386.15	2	384.15	.974	2.3	171.50
86-08-05	220 B NORTH (22-9)	84	1	9.33	14.00	4.67	9846	20	492.30	1.4	490.90	.965	2.3	221.10
86-08-05	220 2ND ELECTRICAL SUBST	85	2	9.75	14.00	4.25	173	20	8.65	1.4	7.25	.968	2.3	3.26
86-08-05	220 OUTSIDE LUNCHROOM	87	1	10.00	14.50	4.50	252	20	12.60	1.2	11.40	.967	2.3	5.13
86-08-05	220 INSIDE LUNCHROOM	89	2	9.92	14.50	4.58	195	20	9.75	.4	9.35	.966	2.3	4.21
86-08-05	170 MAINWAY BY SHIP	928	1	10.33	15.00	4.67	162	20	8.10	.5	7.60	.965	2.3	3.42
86-08-05	170 SHIP	98	2	10.42	15.00	4.58	165	20	9.25	.2	9.05	.966	2.3	4.07
86-08-06	DECLINE REMIX 81	71	1	9.75	14.00	4.25	171	20	8.55	.2	8.35	.968	2.3	3.75
86-08-06	DECLINE BETWEEN DOORS	75	2	10.00	14.00	4.00	84	20	4.20	.8	3.40	.970	2.3	1.52
86-08-06	DECLINE 170/220 SPLIT	74	1	10.25	14.30	4.05	34	20	1.70	1	.70	.970	2.3	.31
86-08-06	220 VENT STATION 42	82	2	10.50	14.30	3.60	16	20	.80	.6	.20	.972	2.3	.09
86-08-06	220 UP 233	83	1	10.75	14.70	3.95	155	20	7.75	0	7.75	.971	2.3	3.47
86-08-06	220 OUTSIDE LUNCHROOM	93	2	11.00	14.70	3.70	226	20	11.30	.6	10.70	.972	2.3	4.78
86-08-06	220 VENT STATION 85 (+110)	72	1	11.00	15.00	4.00	4670	20	233.50	.6	232.90	.970	2.3	104.37
86-08-06	220 VENT STATION 86	97	2	11.25	15.00	3.75	2720	20	136.00	.2	134.00	.972	2.3	59.94
86-08-06	220 VENT STATION 815	80	1	11.50	15.25	3.75	2634	20	131.70	.4	131.10	.972	2.3	58.73
86-08-06	220 VENT STATION 816	78	2	11.50	15.25	3.75	1898	20	94.90	.4	94.50	.972	2.3	42.27
86-08-06	220 VENT STATION 812	94	1	11.75	15.75	4.00	4291	20	214.55	.4	214.15	.970	2.3	95.97
86-08-06	220 RET AIR RAISE FROM 170	96	2	11.75	15.75	5.00	949	20	47.45	0	47.45	.970	2.3	21.26
86-08-06	220 VENT STATION 811	86	1	12.00	17.00	5.00	4384	20	219.30	1	218.30	.963	2.3	96.57
86-08-06	220 VENT STATION 810	90	2	12.25	17.00	4.75	2666	20	130.30	.6	129.70	.965	2.3	58.45
86-08-06	220 VENT STATION 89	77	1	12.25	17.50	5.25	10479	20	523.95	.2	523.75	.961	2.3	235.94
86-08-06	220 VENT STATION 88	73	2	12.50	17.50	5.60	4413	20	320.65	.4	320.25	.963	2.3	144.60
86-08-06	220 VENT STATION 813+	718	1	12.50	18.00	5.50	2955	20	147.75	.4	147.35	.959	2.3	66.79
86-08-07	220 0P230 BEFORE SHIP	418	1	9.25	13.75	4.50	73	20	3.65	.8	2.85	.967	2.3	1.28
86-08-07	220 0P230 AFTER SHIP	85	2	9.25	13.75	4.50	77	20	3.85	.4	3.45	.967	2.3	1.55
86-08-07	220 A3N BLOCKED OFF	758	1	9.60	14.25	4.65	1035	20	51.75	.4	50.75	.965	2.3	22.85
86-08-07	220 835 CROSS CUT 8-1	768	2	10.00	14.25	4.25	9179	20	458.95	1	457.95	.968	2.3	205.61
86-08-07	220 835 CROSS CUT 8-3	688	1	10.00	14.60	4.60	7776	20	388.80	1	387.80	.966	2.3	174.58
86-08-07	220 835 CROSS CUT 8-5	678	2	10.25	14.60	4.35	10794	20	539.70	.8	538.90	.968	2.3	242.14
86-08-07	220 835 CROSS CUT 8-7	84	1	10.25	15.00	4.75	9452	20	472.60	.4	472.20	.965	2.3	212.81
86-08-07	220 835 CROSS CUT 8-9	81	2	10.30	15.00	4.70	11906	20	595.30	1	594.30	.965	2.3	267.74
86-08-07	220 835 CROSS CUT 8-11	98	1	10.50	15.30	4.80	7865	20	393.25	.4	392.85	.964	2.3	177.12
86-08-07	220 835 CROSS CUT 8-13	87	2	10.60	15.30	4.70	5147	20	257.35	.2	257.15	.965	2.3	115.85
86-08-07	220 EXHAUST RAISE FROM 170	928	1	11.00	15.60	4.60	2015	20	100.75	1.2	99.55	.966	2.3	44.81
86-08-07	220 900C MILL MOLE	76	2	11.00	15.50	4.50	93703	5	197415	.6	19740	.967	2.3	8879.51
86-08-07	220 VENT STATION 17-2	79	2	11.50	15.75	4.25	60	20	3	.6	2.4	.968	2.3	1.06
86-08-07	170 746 CROSS CUT ENTER	91	1	11.75	16.00	4.25	501	20	25	.8	24.25	.968	2.3	10.89
86-08-07	170 746 CROSS CUT EXIT	808	2	11.75	17.00	5.25	443	20	32	.4	31.75	.961	2.3	14.36
86-08-07	170 900C MILL MOLE	998	1	11.75	17.00	5.25	906	20	45	1.2	44.10	.961	2.3	19.95
86-08-07	220 900C MILL MOLE	818	2	12.25	17.50	5.25	3929	5	786	.4	785.20	.961	2.3	355.21

APPENDIX A.2

**DATA SPREAD SHEETS
FOR OCTOBER 1986
FIELD PROGRAM**

RADON MEASUREMENT PROGRAM AT CLIFF LANE B-P NINE

RESULTS OF RADON MONITORINGS OCTOBER 1966

DATE	SAMPLE LOCATION	CELL #	COUNTER	SAMPLE TIME	TIME OF COUNT	NET HOURS	TOTAL COUNTS	COUNT TIME (min)	GROSS CPM	CELL RECD	COUNTER RECD	NET CPM	TIME FACTOR	CELL FACTOR	RADON CONC (pCi/L)	RADON DAUGHTERS (dL)	EQUILIBRIUM RATIO
86-10-29	BECLINE-HELIX 2ND DR	76	1	7.75	13.75	6.00	77	10	7.7	1.0	0.4	6.3	0.956	2.3	2.87	0.0099	0.03
86-10-29	170-SUMP	70	2	2.92	13.75	5.85	154	10	15.4	0.0	0.3	15.1	0.937	2.3	6.86	0.0099	0.03
86-10-29	220-45 South	77	1	8.41	14.00	5.50	375	10	37.5	1.0	0.3	35.9	0.959	2.3	16.28	0.0134	-
86-10-29	220-OUTSIDE LUMINOUS	848	2	8.50	14.00	5.50	112	10	11.2	1.9	0.3	9.0	0.959	2.3	4.08	0.0134	-
86-10-29	220-CONCRETE PUMP ROOM	868	1	8.75	14.17	5.42	654	10	65.4	0.0	0.4	64.2	0.960	2.3	29.08	0.0853	0.24
86-10-29	220-ROOM 3-15/CM RIVER	818	2	8.83	14.17	5.34	2840	10	284.0	1.6	0.3	282.9	0.960	2.3	128.07	0.2424	0.19
86-10-29	220-ROOM 4-14	80	1	9.00	14.33	5.33	1848	10	184.8	0.8	0.4	183.4	0.961	2.3	84.01	0.1917	0.23
86-10-29	220-8 South & 82 South	79	2	9.33	14.33	5.00	1780	10	178.0	1.4	0.3	178.1	0.963	2.3	80.42	0.0739	0.09
86-10-29	220-82 South	84	1	9.41	14.58	5.17	356	10	35.6	1.2	0.4	34.0	0.962	2.3	15.37	0.0104	0.07
86-10-29	220-22-25 PAST SUMP	828	2	11.46	14.58	2.92	53	10	5.3	1.5	0.3	3.5	0.978	2.3	1.58	0.0090	0.00
86-10-29	220-835 1-CUT AT 8-1	888	1	11.75	14.75	3.00	1472	10	147.2	1.5	0.4	145.3	0.978	2.3	64.62	0.0488	0.08
86-10-29	220-43 North	88	2	11.92	14.75	2.83	1260	10	126.0	2.0	0.3	117.7	0.979	2.3	52.28	0.1205	0.23
86-10-29	220-170 RET AIR RAISE	87	1	12.12	15.00	2.88	456	10	45.6	2.1	0.4	43.1	0.978	2.3	19.15	0.0235	0.12
86-10-29	220-22-47 TO 22-81	86	2	12.17	15.00	2.83	993	10	99.3	0.3	0.3	98.7	0.979	2.3	43.84	0.1258	0.29
86-10-29	220-22-81 TO 22-79	82	1	12.33	15.25	2.92	781	10	78.1	0.3	0.4	77.4	0.978	2.3	34.40	0.0552	0.25
86-10-29	220-CONCRETE PUMP ROOM	758	2	12.50	15.25	2.75	630	10	63.0	1.0	0.3	61.7	0.979	2.3	27.39	0.0544	0.20
86-10-29	220-835 1-CUT AT 8-10	628	1	17.75	31.25	13.50	1876	10	187.6	0.6	0.4	184.6	0.903	2.3	80.22	0.1675	0.20
86-10-29	220-835 1-CUT AT 8-4	638	2	17.75	31.25	13.50	1514	10	151.4	0.8	0.3	150.3	0.903	2.3	72.37	0.1242	0.17
86-10-29	220-835 1-CUT AT 8-4	618	1	17.75	31.50	13.75	1432	10	143.2	1.0	0.4	141.8	0.901	2.3	68.41	0.2050	0.42
86-10-29	220-835 1-CUT AT 8-4	85	2	17.75	31.50	13.75	1517	10	151.7	0.5	0.3	150.9	0.901	2.3	72.80	0.1225	0.17
86-10-29	220-835 1-CUT AT 8-10	868	1	18.00	31.66	13.66	1657	10	165.7	0.0	0.4	165.3	0.902	2.3	79.49	0.1584	0.20
86-10-29	220-835 1-CUT AT 8-4	688	2	18.00	31.66	13.66	1565	10	156.5	0.6	0.3	155.6	0.902	2.3	75.01	0.2081	0.30
86-10-29	220-835 1-CUT AT 8-4	678	1	18.00	31.83	13.83	1560	10	156.0	0.0	0.4	154.8	0.901	2.3	74.72	0.1815	0.24
86-10-29	220-835 1-CUT AT 8-4	81	2	18.00	31.83	13.83	1610	10	161.0	1.0	0.3	159.7	0.901	2.3	77.09	0.1955	0.25
86-10-29	SURFACE-RET AIR RAISE	83	1	18.00	32.17	16.17	939	10	93.9	1.5	0.4	92.0	0.895	2.3	45.20	0.1051	0.23
86-10-29	220-CONCRETE PUMP ROOM	838	2	17.25	32.17	14.92	496	10	49.6	0.6	0.3	48.7	0.893	2.3	23.70	0.0461	0.19
86-10-30	170-SUMP (start of Th)	898	1	11.17	17.50	6.33	66	10	6.6	1.4	0.4	4.8	0.953	2.3	2.19	0.0041	0.19
86-10-30	SURFACE RET AIR RAISE	91	2	11.87	17.50	5.63	1044	10	104.4	1.4	0.1	102.9	0.950	2.3	46.68	0.0974	0.20
86-10-30	BECLINE-HELIX B-P BLK	768	1	13.87	31.16	17.29	63	10	6.3	1.2	0.2	4.9	0.877	2.3	2.43	0.0020	0.08
86-10-30	220-835 1-CUT AT 8-1	448	2	14.17	31.16	16.99	979	10	97.9	0.8	0.2	96.9	0.879	2.3	47.90	-	-
86-10-30	220-22-47 TO 22-81	90	1	14.25	31.42	17.17	966	10	96.6	1.1	0.2	94.3	0.878	2.3	46.21	-	-
86-10-30	220-170 RET AIR RAISE	71	2	14.33	31.42	17.09	619	10	61.9	1.4	0.2	60.3	0.879	2.3	29.83	-	-
86-10-30	220-22-81 TO 22-79	94	1	14.50	31.66	17.16	845	10	84.5	1.7	0.2	82.6	0.878	2.3	40.89	-	-
86-10-30	220-ROOM 3-15/CM RIVER	73	2	14.48	31.66	17.10	7481	10	748.1	1.2	0.2	744.7	0.870	2.3	349.68	1.4058	0.40
86-10-30	220-22-55 TO 22-53	95	1	15.42	31.83	16.41	1440	10	144.0	0.8	0.2	143.0	0.863	2.3	70.39	-	-
86-10-30	220-57 TO 22-55	738	2	15.50	31.83	16.33	1199	10	119.9	1.2	0.2	118.5	0.864	2.3	58.29	-	-
86-10-30	220-600 OF 8 South	75	1	15.56	32.00	16.52	1066	10	106.6	0.8	0.2	99.6	0.863	2.3	49.06	-	-
86-10-30	220-82 South AT 82	708	2	15.75	32.00	16.33	1111	10	111.1	1.2	0.2	91.7	0.864	2.3	4.77	-	-
86-10-30	170-SUMP (end of Th)	76	1	16.00	32.25	16.25	51	10	5.1	0.4	0.2	4.5	0.894	2.3	2.21	0.0018	0.08
86-10-30	170-17-23 TO 17-26 *	718	2	16.10	32.25	16.15	81	10	8.1	0.0	0.2	7.9	0.885	2.3	3.68	0.0059	0.15
86-10-30	170-17-23 TO 17-26 *	72	1	16.10	32.50	16.40	82	10	8.2	0.8	0.2	7.2	0.885	2.3	3.55	0.0059	0.17

* DONE IN SERIES

RADON MEASUREMENT PROGRAM AT CLIFF LAKE B-P MINE

RESULTS OF RADON DAUGHTER MONITORING DURING 1986

DATE	SAMPLE LOCATION	CELL #	SAMPLE TIME	PUMP NUMBER	PUMP FLOWRATE	TOTAL COUNTS	COUNT TIME (min)	GROSS CPM	COUNTER BIAS	NET CPM	COUNTER EFFICIENCY	CALCULATION TYPE	KUSNETZ FACTOR	RADON DAUGHTERS (dL)	RADON CONC. (pCi/L)	EQUILIBRIUM RATIO
86-10-29	DECLINE-BELOW 2ND DI	76	7.75	5455	2.50	20	3	6.7	5.7	1.0	0.41	ROLLE		0.0009	2.87	0.03
86-10-29	170-SUMP	77	7.92	5455	2.50	20	3	6.7	5.7	1.0	0.41	ROLLE		0.0009	6.86	0.01
86-10-29	220-43 South	78	8.41	5455	2.50	61	3	20.3	5.7	14.6	0.41	ROLLE		0.0134	16.28	0.06
86-10-29	220-OUTSIDE LUNCHROOM	849	8.50	5455	2.50	-	-	-	-	-	-	-	-	-	4.08	-
86-10-29	220-CONCRETE PUMPROOM	848	8.75	5455	2.50	244	3	81.3	5.7	75.6	0.41	ROLLE		0.0493	29.08	0.24
86-10-29	220-ROOM 3-15/FW NIBER	810	8.83	5455	2.50	615	3	276.3	5.7	264.6	0.41	ROLLE		0.2424	128.07	0.19
86-10-29	220-ROOM 4-14	80	9.00	5455	2.50	441	3	215.0	5.7	209.3	0.41	ROLLE		0.1917	84.01	0.23
86-10-29	220-8 South & 82 South	79	9.33	5455	2.50	259	3	86.3	5.7	80.6	0.41	ROLLE		0.0739	80.42	0.09
86-10-29	220-82 South	84	9.41	5455	2.50	51	3	17.0	5.7	11.3	0.41	ROLLE		0.0104	15.37	0.07
86-10-29	220-22-25 PAST SUMP	820	11.44	159	2.40	15	3	5.0	5.7	-0.7	0.41	ROLLE		-0.0007	1.56	-0.04
86-10-29	220-835 I-CUT AT 8-1	880	11.75	5455	2.50	177	3	59.0	5.7	53.3	0.41	ROLLE		0.0468	64.42	0.08
86-10-29	220-43 North	88	11.82	159	2.40	396	3	132.0	5.7	126.3	0.41	ROLLE		0.1205	52.28	0.23
86-10-29	220-170 RET AIR RAISE	87	12.12	5455	2.50	44	3	31.3	5.7	25.4	0.41	ROLLE		0.0235	19.15	0.12
86-10-29	220-22-47 TO 22-61	86	12.17	159	2.40	424	3	84.8	5.7	79.1	0.41	ROLLE		0.1258	43.84	0.29
86-10-29	220-22-61 TO 22-79	82	12.33	159	2.40	205	3	95.0	5.7	89.3	0.41	ROLLE		0.0652	34.40	0.25
86-10-29	220-CONCRETE PUMPROOM	758	12.50	159	2.40	180	3	62.7	5.7	57.0	0.41	ROLLE		0.0544	27.39	0.20
86-10-29	220-835 I-CUT AT 8-10	628	12.75	159	2.40	528	3	176.0	5.7	170.3	0.41	ROLLE		0.1625	80.22	0.20
86-10-29	220-835 I-CUT AT 8-8	638	12.75	1790	6.70	102	3	26.4	5.7	14.7	0.41	KUSNETZ	82.50	0.1242	72.37	0.17
86-10-29	220-835 I-CUT AT 8-6	610	12.75	5450	1.70	386	3	77.2	5.7	71.5	0.41	KUSNETZ	72.00	0.2050	66.41	0.42
86-10-29	220-835 I-CUT AT 8-4	85	12.75	5455	2.50	231	3	46.2	5.7	40.5	0.41	KUSNETZ	64.50	0.1225	72.60	0.17
86-10-29	220-835 I-CUT AT 8-10	848	18.00	159	2.40	515	3	171.7	5.7	166.0	0.41	ROLLE		0.1584	79.49	0.20
86-10-29	220-835 I-CUT AT 8-8	86-10-29	220-835 I-CUT AT 8-6	1790	6.70	155	3	31.0	5.7	25.3	0.41	KUSNETZ	77.30	0.2281	75.01	0.30
86-10-29	220-835 I-CUT AT 8-4	678	18.00	5450	1.70	242	3	48.4	5.7	42.7	0.41	KUSNETZ	67.50	0.1815	74.72	0.24
86-10-29	220-835 I-CUT AT 8-4	81	18.00	5455	2.50	314	3	62.8	5.7	57.1	0.41	KUSNETZ	57.00	0.1925	77.09	0.25
86-10-29	SURFACE-RET AIR RAISE	83	16.00	159	2.40	380	3	76.0	5.7	70.3	0.41	KUSNETZ	136.00	0.1051	45.20	0.23
86-10-29	220-CONCRETE PUMP ROOM	838	17.25	159	2.40	162	3	54.0	5.7	48.3	0.41	ROLLE		0.0461	23.70	0.19
86-10-30	170-SUMP (start of Th)	890	11.17	159	3.00	38	3	7.6	4.8	2.8	0.41	KUSNETZ	112.00	0.0041	2.19	0.19
86-10-30	SURFACE RET AIR RAISE	91	11.87	159	3.00	331	3	66.2	4.8	61.4	0.41	KUSNETZ	108.00	0.0924	44.68	0.20
86-10-30	DECLINE-BEFORE B-P MLE	740	13.87	5455	2.50	21	3	7.0	4.8	2.2	0.41	ROLLE		0.0020	2.43	0.00
86-10-30	220-835 I-CUT AT 8-1	640	14.17	-	-	-	-	-	-	-	-	-	-	-	47.90	-
86-10-30	220-22-47 TO 22-61	90	14.25	-	-	-	-	-	-	-	-	-	-	-	44.21	-
86-10-30	220-170 RET AIR RAISE	71	14.33	-	-	-	-	-	-	-	-	-	-	-	29.83	-
86-10-30	220-22-61 TO 22-79	94	14.50	-	-	-	-	-	-	-	-	-	-	-	40.89	-
86-10-30	220-ROOM 3-15/FW NIBER	73	14.48	5455	2.50	4880	3	1626.7	4.8	1621.9	0.41	ROLLE		1.4858	349.68	0.40
86-10-30	220-22-55 TO 22-53	95	15.42	-	-	-	-	-	-	-	-	-	-	-	70.39	-
86-10-30	220-22-57 TO 22-55	738	15.50	-	-	-	-	-	-	-	-	-	-	-	58.29	-
86-10-30	220-430 OF 8 South	75	15.56	-	-	-	-	-	-	-	-	-	-	-	49.46	-
86-10-30	220-82 South at 82	740	15.75	-	-	-	-	-	-	-	-	-	-	-	4.77	-
86-10-30	170-SUMP (end of Th)	74	16.00	159	2.40	20	3	6.7	4.8	1.9	0.41	ROLLE		0.0018	2.21	0.08
86-10-30	170-17-23 to 17-26 *	718	16.10	159	2.40	33	3	11.0	4.8	4.2	0.41	ROLLE		0.0059	3.88	0.15
86-10-30	170-17-23 to 17-26 *	72	16.10	-	-	-	-	-	-	-	-	-	-	-	3.55	-

* NONE IN SERIES



APPENDIX A.3

**DATA SPREAD SHEETS
FOR OCTOBER 1987
FIELD PROGRAM**

RADON MEASUREMENT PROGRAM AT CLUFF LAKE D-P MINE

RESULTS OF RADON MONITORING OCTOBER 1987

DATE	LEVEL	SITE	DESCRIPTION	CELL	CMT'R	SAMPLE TIME	TIME OF COUNT	NET HOURS	TOTAL COUNTS	COUNT TIME (MIN)	GROSS CPN	BACKGROUND CELL CMT'R	NET COUNTS	TIME FACTOR	CELL FACTOR	RADON CONC (pCi/L)
87-10-16	220	6	220-RETURN RC SIDE	628	1	8:50	13:16	4.66	4724	10	472.4	0.6 0.4	471.4	0.965	2.3	212.3
87-10-16	220	4	170 EXHAUST AT 220	678	2	8:58	13:16	4.58	8102	10	810.2	2.8 0.3	807.1	0.966	2.3	363.3
87-10-16	220	42	MAINWAY AT 835 TOUT	688	1	8:66	13:66	5.00	128	10	12.8	2.0 0.4	10.4	0.963	2.3	4.7
87-10-16	170	20	ABOVE 170 SUNP	71	2	9:66	13:66	4.00	267	10	26.7	2.2 0.3	24.2	0.970	2.3	10.8
87-10-17	220	1	MAINWAY VENT DOOR-SOUTH	91	1	8:58	13:58	5.00	889	10	88.9	1.4 0.4	87.1	0.963	2.3	39.3
87-10-17	220	2	A3 NORTH RETURN AIR	80	2	8:67	13:58	4.91	1914	10	191.4	1.4 0.3	189.7	0.964	2.3	85.6
87-10-17	220	3	MAINWAY BEFORE 170 EXHAUST	89	1	8:83	13:75	4.92	1846	10	184.6	2.4 0.4	181.8	0.963	2.3	82.0
87-10-17	220	4	170 EXHAUST AT 220	87	2	9:02	13:75	4.83	982	10	98.2	1.4 0.3	96.5	0.964	2.3	43.5
87-10-17	220	5	MAINWAY BEFORE EXHAUST	90	1	9:00	14:00	5.00	1476	10	147.6	1.2 0.4	146.0	0.963	2.3	65.9
87-10-17	220	6	RC SILL EXHAUST AT RAISE	828	2	9:08	14:00	4.92	3408	10	340.8	2.6 0.3	337.9	0.963	2.3	152.5
87-10-17	220	7	RC SILL EXHAUST EXIT	848	1	9:16	14:17	5.01	3345	10	334.5	1.4 0.4	332.7	0.963	2.3	150.2
87-10-17	220	42	MAINWAY AT 835 TOUT	808	2	9:33	14:17	4.84	797	10	79.7	1.2 0.3	78.2	0.964	2.3	35.3
87-10-17	220	82	835 TOUT AT B,C SPLIT	818	1	9:42	14:42	5.00	737	10	73.7	1.6 0.4	71.7	0.963	2.3	32.4
87-10-17	220	10	RC CENTRE AT VENT DOORS	84	2	9:42	14:42	5.00	797	10	79.7	1.6 0.3	77.8	0.963	2.3	35.1
87-10-17	220	12	RC NORTH WAMP MILL FACE	85	2	9:75	14:66	4.91	1725	10	172.5	1.8 0.4	170.4	0.964	2.3	76.9
87-10-17	220	E2	RC NORTH-4-B EXIT	81	1	10:00	15:00	5.00	13413	10	1341.3	1.6 0.4	1339.3	0.963	2.3	404.7
87-10-17	220	82	RC CENTRE-B NORTH EXIT	778	2	10:83	15:00	4.17	2487	10	248.7	1.4 0.3	247.0	0.969	2.3	110.8
87-10-17	220	82	RC CENTRE-C NORTH EXIT	758	1	11:00	15:50	4.50	4781	10	478.1	1.2 0.4	476.5	0.967	2.3	214.3
87-10-17	220	16	RC CENTRE-AIR TO B NORTH	92	2	11:25	15:50	4.25	808	10	80.8	1.8 0.3	78.7	0.968	2.3	35.3
87-10-17	220	41	MAINWAY AT A3 ACCESS	79	1	11:50	15:75	4.25	830	10	83.0	1.4 0.4	81.2	0.968	2.3	36.5
87-10-17	220	18	A3 SOUTH SILL ENTER	77	2	11:62	15:75	4.13	938	10	93.8	2.2 0.3	91.3	0.969	2.3	41.0
87-10-18	220	A1	MAINWAY AT A3 ACCESS	70	1	9:50	13:50	4.00	244	10	24.4	1.4 0.2	22.8	0.970	2.3	10.2
87-10-18	220	A2	MAINWAY AT 835 TOUT	928	2	9:44	13:50	3.84	258	10	25.8	0.6 0.3	24.9	0.971	2.3	11.1
87-10-18	220	B1	835 TOUT AT MAINWAY	96	1	9:83	13:83	4.00	231	10	23.1	1.0 0.2	21.9	0.970	2.3	9.8
87-10-18	220	B2	835 TOUT AT B,C SPLIT	76	2	10:00	13:83	3.83	267	10	26.7	1.4 0.3	25.0	0.971	2.3	11.2
87-10-18	220	C1	RC CENTRE-C NORTH FACE	738	2	10:25	14:25	4.00	1496	10	149.6	0.4 0.3	148.9	0.970	2.3	66.7
87-10-18	220	C2	RC CENTRE-C NORTH EXIT	72	1	10:42	14:46	4.24	4226	10	422.6	1.1 0.2	421.3	0.968	2.3	189.1
87-10-18	220	E1	RC NORTH-4-B FACE	718	2	10:44	14:46	4.00	1442	10	144.2	1.6 0.3	142.3	0.970	2.3	63.8
87-10-18	220	E2	RC NORTH-4-B EXIT	83	1	10:75	14:83	4.08	1417	10	141.7	2.0 0.2	139.5	0.970	2.3	62.6
87-10-18	220	2	A3 NORTH RETURN AIR	74	2	11:17	14:83	3.46	1689	10	168.9	1.8 0.3	166.8	0.973	2.3	74.6
87-10-18	220	4	170 EXHAUST AT 220	648	1	11:33	15:33	4.00	884	10	88.4	2.0 0.2	84.2	0.970	2.3	37.7
87-10-18	220	7	RC SILL EXHAUST EXIT	768	2	11:47	15:33	3.91	2638	10	263.8	2.6 0.3	260.9	0.971	2.3	125.8
87-10-18	220	5	MAINWAY BEFORE EXHAUST	638	1	11:50	15:58	4.08	1284	10	128.4	2.0 0.2	124.2	0.970	2.3	55.7
87-10-18	220	18	A3 SOUTH SILL ENTER	888	2	11:83	15:58	3.75	469	10	46.9	3.2 0.3	43.4	0.972	2.3	19.4
87-10-18	245	19	EXHAUST AIR AT SURFACE	80	1	12:08	15:83	3.75	2422	10	242.2	2.8 0.2	239.2	0.972	2.3	107.0
87-10-19	220	18	A3 SOUTH SILL ENTER	6	1	14:75	37:33	22.58	277	10	27.7	2.0 0.35	25.3	0.843	2.3	13.1
87-10-19	220	A1	MAINWAY AT A3 ACCESS	18	2	15:00	37:33	22.33	180	10	18.0	2.0 0.30	15.7	0.845	2.3	8.1
87-10-19	220	A2	MAINWAY AT 835 TOUT	21	1	15:17	37:50	22.33	147	10	14.7	2.0 0.35	12.4	0.845	2.3	6.4
87-10-19	220	B1	835 TOUT AT MAINWAY	94	2	15:33	37:50	22.17	189	10	18.9	0.8 0.30	17.8	0.846	2.3	9.2
87-10-19	220	B2	835 TOUT AT B,C SPLIT	838	1	15:50	37:75	22.25	168	10	16.8	2.4 0.35	16.1	0.845	2.3	8.3
87-10-19	220	C1	RC CENTRE-C NORTH FACE	14	2	15:83	37:75	21.92	1114	10	111.4	2.0 0.30	109.1	0.847	2.3	56.0

07-10-19 220	14	1	16.17	39.00	21.83	1269	10	126.9	2.0	0.35	124.6	0.848	2.3	63.3
H2 A3 NORTH RETURN AIR														
4 170 EXHAUST AT 220	98	2	16.33	38.00	21.67	2013	10	201.3	2.0	0.30	199.0	0.849	2.3	101.1
7 BC STILL EXHAUST	4	1	16.50	38.25	21.75	2933	10	293.3	2.0	0.35	291.0	0.848	2.3	149.1
5 MAINWAY BEFORE EXHAUST	508	2	16.66	38.25	21.59	1677	10	167.7	2.0	0.30	165.4	0.849	2.3	84.7
07-10-20 220	820	1	9.75	14.33	4.58	408	10	40.8	2.4	0.30	38.1	0.966	2.3	17.1
H1 A3 SOUTH SILL ENTER														
A1 MAINWAY AT A3 ACCESS	818	2	9.92	14.33	4.41	146	10	14.6	2.2	0.30	12.1	0.967	2.3	5.4
A2 MAINWAY AT B3 ACCESS	848	1	10.08	14.75	4.67	174	10	17.4	1.2	0.35	15.8	0.965	2.3	7.1
B1 B35 ICUT AT MAINWAY	77	2	10.25	14.75	4.50	228	10	22.8	2.2	0.30	20.3	0.967	2.3	9.1
B2 B35 ICUT AT 0,C SPLIT	88	1	10.33	15.00	4.67	286	10	28.6	2.2	0.35	27.1	0.965	2.3	12.2
F1 BC CENTRE- C NORTH FACE	79	2	10.50	15.00	4.50	1499	10	149.9	2.4	0.30	147.2	0.967	2.3	66.2
F2 BC CENTRE- C NORTH EXHAUST	84	1	10.58	15.17	4.59	1711	10	171.1	1.2	0.35	169.5	0.966	2.3	76.3
G1 BC CENTRE- C NORTH FACE	81	2	10.67	15.17	4.50	2938	10	293.8	3.0	0.30	290.5	0.967	2.3	130.7
G2 BC NORTH- C1 FACE	71	1	11.08	15.33	4.25	2140	10	214.0	1.2	0.35	212.5	0.968	2.3	95.2
H2 BC NORTH- C1 EXHAUST	87	2	11.17	15.33	4.16	2314	10	231.4	2.4	0.30	228.3	0.969	2.3	102.2
H3 A3 NORTH RETURN AIR	85	1	11.33	15.58	4.25	1682	10	168.2	2.4	0.35	165.5	0.968	2.3	74.3
4 170 EXHAUST AT 220	80	2	11.42	15.58	4.16	1891	10	189.1	2.4	0.30	186.4	0.969	2.3	83.6
7 BC SILL EXHAUST	91	1	11.58	15.75	4.17	2696	10	269.6	2.2	0.35	267.1	0.969	2.3	119.8
5 MAINWAY BEFORE EXHAUST	758	2	11.67	15.75	4.08	1517	10	151.7	2.4	0.30	149.0	0.970	2.3	66.8
19 RETURN AIR AT SURFACE	92	1	12.08	16.00	3.92	2095	10	209.5	2.4	0.35	206.8	0.971	2.3	92.6
19 RETURN AIR AT SURFACE	90	2	12.08	16.00	3.92	2198	10	219.8	2.2	0.30	217.3	0.971	2.3	97.3
07-10-21 220	93	1	7.75	13.92	6.17	803	20	40.2	1.4	0.55	38.2	0.954	2.3	17.4
H1 A3 SOUTH SILL ENTER														
A1 MAINWAY AT A3 ACCESS	76	2	7.83	13.92	6.09	154	10	15.4	2.4	0.37	12.6	0.955	2.3	5.8
A2 MAINWAY AT B3 ACCESS	678	1	7.92	14.25	6.33	248	10	24.8	0.8	0.55	23.5	0.953	2.3	10.7
B1 B35 ICUT AT MAINWAY	638	2	8.00	14.25	6.25	257	10	25.7	1.8	0.37	23.5	0.954	2.3	10.7
B2 B35 ICUT AT 0,C SPLIT	87	1	8.16	14.50	6.34	287	10	28.7	2.0	0.55	26.2	0.953	2.3	11.9
C1 BC CENTRE- C1,C2 FACE	738	2	8.25	14.50	6.25	1045	10	104.5	2.0	0.37	102.1	0.954	2.3	46.6
C2 BC CENTRE- C1,C2 EXHAUST	95	1	8.42	14.75	6.33	1362	10	136.2	2.0	0.55	133.6	0.953	2.3	61.0
F1 BC CENTRE- C NORTH FACE	82	2	8.42	14.75	6.33	2365	10	230.5	1.2	0.37	227.9	0.953	2.3	104.0
F2 BC CENTRE- C NORTH EXHAUST	75	1	8.50	15.00	6.50	5717	10	571.7	1.8	0.55	569.4	0.952	2.3	286.0
G2 BC NORTH- C1 EXHAUST	55	2	8.63	15.00	6.37	4396	10	439.6	1.6	0.37	437.6	0.953	2.3	199.7
H2 A3 NORTH RETURN AIR	778	1	8.83	15.16	6.33	1585	10	158.5	1.2	0.55	156.8	0.953	2.3	71.5
4 170 EXHAUST AT 220	748	2	8.92	15.16	6.24	1284	10	128.4	1.2	0.37	124.8	0.954	2.3	56.9
7 BC SILL EXHAUST	929	1	9.08	15.42	6.34	2794	10	279.4	2.4	0.55	276.5	0.953	2.3	126.1
5 MAINWAY BEFORE EXHAUST	878	2	9.16	15.42	6.26	1308	10	130.8	2.4	0.37	128.0	0.954	2.3	58.4
G1 BC NORTH- C1 FACE	468	1	9.58	15.66	6.08	2422	10	242.2	1.8	0.55	239.9	0.955	2.3	109.2
G2 BC NORTH- C1 EXHAUST	478	2	9.58	15.66	6.08	1735	10	173.5	2.4	0.37	170.7	0.955	2.3	77.7
F1 BC CENTRE- C NORTH FACE	57	1	9.75	15.83	6.08	3922	10	392.2	1.4	0.55	390.3	0.955	2.3	177.7
F2 BC CENTRE- C NORTH EXHAUST	31	2	9.83	15.83	6.00	2489	10	248.9	2.4	0.37	246.1	0.956	2.3	112.0
C2 BC CENTRE- C1,C2 EXHAUST	34	1	10.08	16.08	6.00	1755	10	175.5	2.4	0.55	172.6	0.956	2.3	78.5
C1 BC CENTRE- C1,C2 FACE	72	2	10.16	16.08	5.92	1351	10	135.1	2.0	0.37	132.7	0.956	2.3	60.4
H1 BC CENTRE- B NORTH FACE	598	1	10.50	16.42	5.92	903	10	90.3	2.0	0.55	87.8	0.956	2.3	39.9
G2 BC CENTRE- B NORTH EXHAUST	97	2	10.66	16.42	5.76	2064	10	206.4	1.8	0.37	204.2	0.957	2.3	92.7
G1 BC NORTH- C1 FACE	608	1	11.08	16.66	5.58	2559	10	255.9	2.6	0.55	252.8	0.959	2.3	114.6
G2 BC NORTH- C1 EXHAUST	68	2	11.16	16.66	5.50	3255	10	325.5	1.0	0.37	324.1	0.959	2.3	146.9
21 DECLINE EXHAUST AT SURFACE	90	1	12.25	16.83	4.58	84	10	8.4	0.8	0.55	7.1	0.966	2.3	3.2
19 RETURN AIR AT SURFACE	44	2	12.42	16.83	4.41	3730	10	373.0	2.2	0.37	370.4	0.967	2.3	166.5
07-10-22 220	84	1	7.92	13.58	5.66	353	10	35.3	2.40	0.29	32.6	0.958	2.3	14.0
H1 A3 SOUTH SILL ENTER														
A1 MAINWAY AT A3 ACCESS	94	2	8.08	13.58	5.50	180	10	18.0	1.00	0.33	17.5	0.959	2.3	7.9
A2 MAINWAY AT B3 ACCESS	91	1	8.33	13.75	5.42	176	10	17.6	3.00	0.29	14.3	0.960	2.3	6.3
B1 B35 ICUT AT MAINWAY	85	2	8.33	13.75	5.42	209	10	20.9	2.00	0.33	18.6	0.960	2.3	8.4
B2 B35 ICUT AT 0,C SPLIT	96	1	8.42	14.16	5.74	268	10	26.8	2.20	0.29	18.3	0.958	2.3	8.3
G1 BC CENTRE- B NORTH FACE	77	2	8.58	14.16	5.58	2272	10	227.2	1.80	0.33	225.1	0.959	2.3	102.1
G2 BC CENTRE- B NORTH EXHAUST	80	1	8.66	14.50	5.84	1776	10	177.6	2.40	0.29	174.4	0.957	2.3	79.5

87-10-22 220	F1 BC CENTRE- C NORTH FACE	78	2	8.83	14.50	5.67	1048	10	104.8	1.00	0.33	103.5	0.958	2.3	47.0
87-10-22 220	F2 BC CENTRE- C NORTH EXHAUST	89	1	8.92	14.66	5.74	1414	10	141.4	2.80	0.29	138.3	0.958	2.3	62.8
87-10-22 220	C1 BC CENTRE-C1,C1 FACE	92	2	9.00	14.66	5.66	1885	10	188.5	3.40	0.33	184.8	0.958	2.3	83.8
87-10-22 220	C2 BC CENTRE-C1,C1 EXHAUST	648	1	9.00	14.92	5.92	1356	10	135.6	2.80	0.29	132.5	0.956	2.3	60.3
87-10-22 220	E2 BC NORTH- C1 EXHAUST	74	2	9.16	14.92	5.76	1400	10	140.0	2.20	0.33	137.5	0.957	2.3	62.4
87-10-22 220	E1 BC NORTH- C1 FACE	90	1	9.25	15.25	6.00	2820	10	282.0	1.20	0.29	280.5	0.956	2.3	127.6
87-10-22 220	K2 A3 NORTH RETURN AIR	71	2	9.50	15.25	5.75	1711	10	171.1	1.00	0.33	169.8	0.957	2.3	77.1
87-10-22 220	4 170 EXHAUST AT 220	83	1	9.66	15.50	5.84	1337	10	133.7	2.20	0.29	131.2	0.957	2.3	59.5
87-10-22 220	7 BC SILL EXHAUST	79	2	9.66	15.50	5.84	2931	10	293.1	1.40	0.33	291.4	0.957	2.3	132.4
87-10-22 220	5 MAINWAY BEFORE EXHAUST	718	1	9.83	15.66	5.83	1711	10	171.1	3.20	0.29	167.6	0.957	2.3	76.2
87-10-22 220	20 ABOVE 170 SUMP	68	2	10.08	15.66	5.58	118	10	11.8	2.20	0.33	9.3	0.959	2.3	4.2
87-10-22 220	21 DECLINE AT 220 LEVEL	39	1	10.92	16.33	5.41	57	20	2.9	2.80	0.29	0.6	0.960	2.3	0.3
87-10-22 220	22 DECLINE EXHAUST AT SURFACE	58	2	12.16	16.33	4.17	217	20	10.9	1.80	0.33	8.7	0.969	2.3	3.9
87-10-22 220	19 RETURN AIR AT SURFACE	52	1	12.25	16.66	4.41	2484	10	248.4	1.80	0.29	246.3	0.967	2.3	110.7

RADON MEASUREMENT PROGRAM AT CLIFF LAKE B-P MINE

RESULTS OF RADON DAUGHTER MEASUREMENTS OCTOBER 1987

DATE	LEVEL	SITE	DESCRIPTION	CELL	SAMPLE #	PUMP #	PUMP FLOW (lpm)	PUMP TOTAL COUNTS	COUNT TIME (min)	GROSS CPM	COUNTER RSGD	NET CPM	COUNTER EFF. (%)	CALC TYPE	KUSNETZ FACTOR	RADON DIMS (mL)	RADON CONC (pCi/L)	"E" RATIO
87-10-17	220	B2	BC CENTRE-B NORTH EXIT	778	10-83	3485	2.4	556	3	185.3	8.7	176.6	0.36	ROLLE		0.192	110.8	0.17
87-10-17	220	C2	BC CENTRE-C NORTH EXIT	758	11-00	3485	2.4	1055	3	351.7	8.7	343.0	0.36	ROLLE		0.373	214.3	0.17
87-10-17	220	1A	BC CENTRE-AIR TO B NORTH	92	11-25	3485	2.4	355	3	118.3	8.7	109.6	0.36	ROLLE		0.119	35.3	0.34
87-10-17	220	1E	A3 SOUTH SILL INTRO	77	11-62	3485	2.4	543	4	135.8	8.7	127.1	0.36	ROLLE		0.184	41.0	0.45
87-10-18	220	A1	MAINWAY AT A3 ACCESS	78	9-50	5455	2.6	62	3	20.7	2.6	18.1	0.36	ROLLE		0.018	10.2	0.18
87-10-18	220	A2	MAINWAY AT B35 ICUT	928	9-66	5455	2.6	87	3	29.0	2.6	26.4	0.36	ROLLE		0.026	11.1	0.24
87-10-18	220	B1	B35 ICUT AT MAINWAY	96	9-83	5455	2.6	95	3	31.7	2.6	29.1	0.36	ROLLE		0.029	9.8	0.30
87-10-18	220	B2	B35 ICUT AT BC SPLIT	76	10-00	5455	2.6	89	3	29.7	2.6	27.1	0.36	ROLLE		0.027	11.2	0.24
87-10-18	220	F1	BC CENTRE-C NORTH FACE	82	10-25	5455	2.6	149	3	49.7	2.6	47.1	0.36	ROLLE		0.047	12.1	0.39
87-10-18	220	C2	BC CENTRE-C NORTH EXIT	72	10-42	5455	2.6	623	3	207.7	2.6	205.1	0.36	ROLLE		0.206	66.7	0.31
87-10-18	220	E1	BC NORTH- 4-B FACE	718	10-66	5455	2.6	272	3	90.7	2.6	88.1	0.36	ROLLE		0.088	189.1	0.05
87-10-18	220	E2	BC NORTH- 4-B EXIT	83	10-75	5455	2.6	56	3	19.7	2.6	16.1	0.36	ROLLE		0.016	62.6	0.03
87-10-18	220	H2	A3 NORTH RETURN AIR	74	11-17	5455	2.6	585	3	195.0	2.6	192.4	0.36	ROLLE		0.193	74.6	0.26
87-10-18	220	4	170 EXHAUST AT 220	648	11-33	5455	2.6	272	3	90.7	2.6	88.1	0.36	ROLLE		0.088	37.7	0.23
87-10-18	220	7	BC SILL EXHAUST EXIT	768	11-42	5455	2.6	708	3	236.0	2.6	233.4	0.36	ROLLE		0.234	125.8	0.19
87-10-18	220	5	MAINWAY BEFORE RTN AIR RAI	638	11-50	5455	2.6	374	3	124.7	2.6	122.1	0.36	ROLLE		0.122	55.7	0.22
87-10-18	225	H1	A3 SOUTH SILL ENTER	888	11-83	5455	2.6	127	3.4	37.4	2.6	34.8	0.36	ROLLE		0.040	39.4	0.20
87-10-18	265	19	RETURN AIR AT SURFACE	89	12-08	5455	2.6	583	3	194.3	2.6	191.7	0.36	ROLLE		0.192	107.0	0.18
87-10-19	220	H1	A3 SOUTH SILL ENTER	6	14-75	5455	2.6	114	3	38.0	5.6	32.4	0.36	ROLLE		0.033	13.1	0.25
87-10-19	220	A1	MAINWAY AT A3 SOUTH	18	15-00	5455	2.6	66	3	22.0	5.6	16.4	0.36	ROLLE		0.016	8.1	0.20
87-10-19	220	A2	MAINWAY AT B35 ICUT	21	15-17	5455	2.6	61	3	20.3	5.6	14.7	0.36	ROLLE		0.015	6.4	0.23
87-10-19	220	B1	B35 ICUT AT MAINWAY	94	15-33	5455	2.6	95	3	31.7	5.6	26.1	0.36	ROLLE		0.026	9.2	0.28
87-10-19	220	B2	B35 ICUT AT BC SPLIT	838	15-50	5455	2.6	93	3	31.0	5.6	25.4	0.36	ROLLE		0.025	8.3	0.31
87-10-19	220	C1	BC CENTRE-C NORTH FACE	16	15-83	5455	2.6	303	3	101.0	5.6	95.4	0.36	ROLLE		0.096	56.0	0.17
87-10-19	220	H2	A3 NORTH RETURN AIR	14	16-17	5455	2.6	530	3	176.7	5.6	171.1	0.36	ROLLE		0.172	63.9	0.27
87-10-19	220	4	170 EXHAUST AT 220	98	16-33	5455	2.6	654	3	218.0	5.6	212.4	0.36	ROLLE		0.213	101.9	0.21
87-10-19	220	7	BC SILL EXHAUST EXIT	4	16-50	5455	2.6	695	3	231.7	5.6	226.1	0.36	ROLLE		0.227	149.1	0.15
87-10-19	220	5	MAINWAY BEFORE RTN AIR RAI	588	16-66	5455	2.6	543	3.5	155.1	5.6	149.5	0.36	ROLLE		0.175	84.7	0.21
87-10-20	220	H1	A3 SOUTH SILL ENTER	828	9-75	3485	2.5	110	3	26.7	8.3	28.4	0.41	ROLLE		0.026	17.1	0.15
87-10-20	220	A1	MAINWAY AT A3 SOUTH	818	9-92	3485	2.5	57	3	19.0	8.3	10.7	0.41	ROLLE		0.010	5.4	0.18
87-10-20	220	A2	MAINWAY AT B35 ICUT	848	10-08	3485	2.5	58	3	19.3	8.3	11.0	0.41	ROLLE		0.010	7.1	0.14
87-10-20	220	B1	B35 ICUT AT MAINWAY	77	10-25	3485	2.5	43	2.6	24.2	8.3	15.9	0.41	ROLLE		0.013	9.1	0.14
87-10-20	220	B2	B35 ICUT AT BC SPLIT	88	10-33	3485	2.5	80	3	26.7	8.3	18.4	0.41	ROLLE		0.017	12.2	0.14
87-10-20	220	F1	BC CENTRE-C NORTH FACE	79	10-50	3485	2.5	315	3	105.0	8.3	96.7	0.41	ROLLE		0.089	66.2	0.13
87-10-20	220	F2	BC CENTRE-C NORTH EXIT	84	10-58	3485	2.5	357	3	119.0	8.3	110.7	0.41	ROLLE		0.101	76.3	0.13
87-10-20	220	G1	BC NORTH- C1 FACE	71	11-06	3485	2.5	262	3	87.3	8.3	79.0	0.41	ROLLE		0.072	95.4	0.08
87-10-20	220	G2	BC NORTH- C1 EXIT	89	11-17	3485	2.5	266	2.5	106.4	8.3	98.1	0.41	ROLLE		0.075	102.4	0.07
87-10-20	220	H2	A3 NORTH RETURN AIR	85	11-33	3485	2.5	711	3	237.0	8.3	228.7	0.41	ROLLE		0.210	74.3	0.28
87-10-20	220	4	170 EXHAUST AT 220	80	11-43	3485	2.5	455	3	151.7	8.3	143.4	0.41	ROLLE		0.131	83.6	0.16
87-10-20	220	7	BC SILL EXHAUST EXIT	91	11-58	3485	2.5	638	3	212.7	8.3	204.4	0.41	ROLLE		0.187	119.8	0.16

87-10-20	220	5 MAINWAY BEFORE RTN AIR RAI 750	11.67	3485	2.5	452	3	150.7	8.3	142.4	0.41	ROLLE	0.130	66.8	0.20
87-10-20	245	19 RETURN AIR AT SURFACE	12.08	3485	2.5	559	3	189.3	8.3	181.0	0.41	ROLLE	0.166	92.6	0.18
87-10-21	220	F1 BC CENTRE-C NORTH FACE	9.75	2789	2.6	619	3	206.3	10.0	196.3	0.36	ROLLE	0.197	177.7	0.11
87-10-21	220	F2 BC CENTRE-C NORTH EXIT	9.83	2789	2.6	373	3	131.0	10.0	121.0	0.36	ROLLE	0.121	112.0	0.11
87-10-21	220	C2 BC CENTRE-C1, C2 EXIT	54	2789	2.6	351	3	117.0	10.0	107.0	0.36	ROLLE	0.107	78.5	0.14
87-10-21	220	C1 BC CENTRE-C1, C2 FACE	72	2789	2.6	206	3	66.7	10.0	56.7	0.36	ROLLE	0.057	60.4	0.09
87-10-21	220	B1 BC CENTRE- B FACE	598	2789	2.6	243	3	81.0	10.0	71.0	0.36	ROLLE	0.071	39.9	0.18
87-10-21	220	B2 BC CENTRE- B EXIT	97	2789	2.6	376	3	108.7	10.0	98.7	0.36	ROLLE	0.099	92.7	0.11
87-10-21	220	G1 BC NORTH- C1 FACE	800	2789	2.6	290	3	96.7	10.0	86.7	0.36	ROLLE	0.087	114.6	0.08
87-10-21	220	G2 BC NORTH- C1 EXIT	48	2789	2.6	329	3	109.7	10.0	99.7	0.36	ROLLE	0.100	146.9	0.07
87-10-21	245	19 RETURN AIR AT SURFACE	12.42	2789	2.6	691	3	230.3	10.0	220.3	0.36	ROLLE	0.221	166.5	0.13
87-10-22	220	A2 MAINWAY AT 835 TOUT	11.33	2789	2.6	59	3	19.7	9.2	10.5	0.36	ROLLE	0.011	6.5	0.16
87-10-22	220	4 170 EXHAUST AT 220	11.50	2789	2.6	519	3	173.0	9.2	163.8	0.36	ROLLE	0.164	59.6	0.28
87-10-22	220	7 BC SILL EXHAUST EXIT	11.58	2789	2.6	1166	3	388.7	9.2	379.5	0.36	ROLLE	0.381	132.4	0.29
87-10-22	245	19 RETURN AIR AT SURFACE	12.25	2789	2.6	683	3	221.0	9.2	211.8	0.36	ROLLE	0.212	110.7	0.19
87-10-22	220	F1 BC CENTRE-C NORTH FACE	8.00									ROLLE	0.057	47.0	0.11
87-10-22	220	G1 BC NORTH- C1 FACE	8.25									ROLLE	0.061	127.6	0.05
87-10-22	220	B1 BC CENTRE- B FACE	8.50									ROLLE	0.063	102.1	0.06

APPENDIX A.4

**RADON FLUX RESULTS
BY ROCK TYPE**

Appendix Table A.4 RADON FLUX RESULTS BY ROCK TYPE

DATE	ROCK TYPE	RADON FLUX (pCi/m2.sec)	DATE	ROCK TYPE	RADON FLUX (pCi/m2.sec)	DATE	ROCK TYPE	RADON FLUX (pCi/m2.sec)
OCT.20	Ore.1	57.9	AUG.6	Ster.1	2.7	OCT.29	Ster.3	342.9
OCT.17	Ore.1	77.8	OCT.21	Ster.1	3.3	OCT.29	Ster.3	628.6
OCT.30	Ore.1	92.4	OCT.22	Ster.1	4.0	AUG.7	Ster.3	1192.6
OCT.22	Ore.1	134.3	AUG.6	Ster.1	6.9	AUG.7	Ster.3	1518.7
OCT.21	Ore.1	142.8	OCT.18	Ster.1	8.8	AUG.7	Ster.3	2976.5
OCT.21	Ore.1	179.5	OCT.20	Ster.1	14.6	AUG.7	Ster.3	3149.2
OCT.18	Ore.1	276.1	AUG.6	Ster.1	16.2	AUG.7	Ster.3	3205.1
OCT.21	Ore.1	334.6	OCT.16	Ster.1	22.5	AUG.7	Ster.3	3281.3
OCT.17	Ore.1	344.9	OCT.29	Ster.1	31.1	AUG.7	Ster.3	6217.1
OCT.21	Ore.1	407.3	AUG.7	Ster.1	31.4	AUG.7	Ster.3	7710.5
OCT.30	Ore.1	457.3	AUG.5	Ster.1	34.2	AUG.7	Ster.3	9203.8
OCT.21	Ore.1	775.9	OCT.21	Ster.1	39.1			
OCT.17	Ore.1	937.8						
AUG.6	Ore.1	3631.0	Number		12	Number		11
AUG.6	Ore.1	6452.8	Average		18	Average		3584
OCT.30	Ore.1	14000.0	Maximum		39	Maximum		9204
			Minimum		3	Minimum		343
Number		16						
Average		1769						
Maximum		14000						
Minimum		58						
Number		13						
Average 2		325						
AUG.6	Ore.2	10.9	OCT.21	Ster.2	35.0	AUG.7	Ster.4	29.2
OCT.20	Ore.2	17.3	OCT.18	Ster.2	40.0	OCT.30	Ster.4	56.1
AUG.7	Ore.2	43.0	OCT.18	Ster.2	65.7	OCT.30	Ster.4	73.4
OCT.21	Ore.2	72.9	OCT.20	Ster.2	82.5	AUG.7	Ster.4	103.8
OCT.17	Ore.2	74.8						
OCT.19	Ore.2	86.9	Number		4	Number		4
OCT.21	Ore.2	92.5	Average		56	Average		66
OCT.18	Ore.2	92.5	Maximum		83	Maximum		104
OCT.20	Ore.2	96.3	Minimum		35	Minimum		29
OCT.22	Ore.2	99.9						
AUG.5	Ore.2	103.6						
AUG.6	Ore.2	106.5						
AUG.6	Ore.2	148.6						
OCT.29	Ore.2	153.9						
AUG.6	Ore.2	967.0						
Number		15						
Average		144						
Maximum		967						
Minimum		11						

APPENDIX B.1

**VENTILATION PROGRAM
BRANCH NETWORK INPUT FILE**

BRANCH INPUT FILE

LEGEND

Maximum Number of Iterations Required Precision Maximum Number of Iterations Radon Program Detailed Printout Code for Radon Program

	30	0.005	30	0				
10	1	3	0.	50.0	1.0		0.	0.
20	1	3	0.	50.0	1.0	0.0		
10	11	1	0.013	-50.0			100.	10.
11	12	1	0.013	-25.0			100.	10.
1	40	1	0.0	50.0				
40	41	1	0.017	50.0			300.	15.
41	42	1	0.017	25.0			300.	15.
1	30	1	0.0	50.0				
30	31	1	0.003	50.0			100.	24.
31	32	1	0.003	50.0			100.	24.
20	21	1	0.013	50.0			100.	10.
21	22	1	0.013	25.0			100.	10.
31	41	1	0.005	25.0			50.	12.
32	42	1	0.005	25.0			50.	12.
41	21	1	0.050	25.0			500.	12.
41	11	1	0.050	25.0			500.	12.
42	22	1	0.050	25.0			500.	12.
42	51	1	0.020	25.0			200.	12.
51	53	1	0.010	50.0			100.	12.
53	12	1	0.020	25.0			200.	12.
53	52	1	0.010	25.0			100.	12.
52	51	3	0.010	25.0	2.0		100.	12.

0

30

0.005

30

0

2.0

→ Branch Cross Sectional Area (m²)

→ Branch Length (m)

→ Natural Ventilation Pressure

→ Additional Information

→ Preliminary Flow Estimate (m³/s)

→ Branch Resistance

→ Branch Type

→ Final Node

→ Initial Node

→ End of File

BRANCH.DAT

	600	1.00	30	0		1.00	28.00
1 2	4 0.0000054	80.00	80.00		1.00	28.00	
2 2202	1 0.0004031	80.00		0.00	75.00	28.00	
2202 2211	1 0.0048700	45.00			10.00	20.00	
2202 1702	1 0.0002687	35.00			50.00	28.00	
2211 2223	1 0.0039661	50.00			100.00	16.60	
2223 2225	1 0.0024986	40.00			63.00	16.60	
2225 2226	3 3.6590778	6.00	10.00		40.00	0.46	
2226 2227	1 0.0020651	6.00			30.00	16.00	
2227 2229	1 0.0056702	6.00			40.00	12.00	
1703 2203	1 0.5762094	0.50			50.00	3.00	
2203 2229	1 0.0002835	0.50			2.00	12.00	
2229 2231	1 0.0021263	6.50			15.00	12.00	
1704 2204	1 0.5762094	0.50			50.00	3.00	
2204 2231	1 0.0021263	0.50			15.00	12.00	
2231 2235	1 0.0035439	7.00			25.00	12.00	
1705 2205	1 0.5762094	0.50			50.00	3.00	
2205 2235	1 0.0007879	0.50			5.00	11.50	
2235 2236	1 0.0176093	7.50			100.00	11.00	
1755 2242	1 0.5762094	0.50			50.00	3.00	
2242 2236	1 0.0009093	0.50			4.00	10.00	
2236 2238	1 0.0051796	8.00			20.00	9.50	
1766 2244	1 0.5762094	0.50			50.00	3.00	
2244 2238	1 0.0044238	0.50			15.00	9.00	
2238 2240	1 0.0044238	8.50			15.00	9.00	
1767 2246	1 0.5762094	0.50			50.00	3.00	
2246 2240	1 0.0008848	0.50			3.00	9.00	
2240 2245	1 0.0221924	9.00			60.00	8.23	
2245 2249	1 0.0020466	9.00			25.00	13.20	
2225 2243	1 0.0064047	34.00			213.90	18.56	
2243 2247	1 0.0002994	6.00			10.00	18.56	
2247 2249	4 0.0004046	0.10	0.10		12.00	17.70	
2247 2279	3 0.4709066	5.50	2.00		105.00	0.46	
2249 2281	1 0.0023941	9.50			71.00	17.70	
1707 2207	1 0.0089876	15.00			50.00	8.16	
2207 2281	1 0.0002045	15.00			4.00	15.00	
2281 2279	1 0.0005058	24.50			15.00	17.70	
2279 79	1 0.0033574	54.00			75.00	12.00	
2243 2254	1 0.0031486	28.00			66.84	15.48	
2254 2252	1 0.0010673	16.00			11.50	11.80	
2252 2031	3 0.0059395	16.00	9.00		64.00	11.80	
2031 2033	1 0.0012975	10.00			10.00	11.00	
2031 2044	319.0272047	6.00	3.00		104.00	0.46	
2033 2032	1 0.1263392	7.00			37.00	3.00	
2033 2037	327.9053409	3.00	12.00		108.00	0.46	
2036 2032	1 0.0166948	1.00			41.40	7.24	
2032 2040	1 0.0478040	-3.00			14.00	3.00	
2032 2256	1 0.0146339	8.00			4.00	3.00	
2032 2034	1 0.0146339	3.00			4.00	3.00	
2037 2036	1 0.0170834	3.00			27.30	7.24	
2036 2039	1 0.0036585	1.00			1.00	3.00	
2036 2256	1 0.0341457	1.00			10.00	3.00	
2044 2040	1 0.0940085	6.00			72.20	4.53	

2040 2042	1 0.0036585	3.00		1.00	3.00
2039 1706	1 4.4779700	-1.00		40.00	3.00
2042 1709	1 1.0926637	1.00		40.00	3.00
2034 1708	1 1.0926637	0.50		40.00	3.00
2223 2224	1 0.0045453	10.00		17.00	7.80
2224 2004	3 0.0085559	10.00	8.00	32.00	7.80
2004 2006	1 0.0012376	0.50		4.00	9.00
2006 1719	1 4.4779700	0.50		40.00	3.00
2004 2010	3 3.4761239	3.50	10.00	19.00	0.46
2010 2008	1 0.0031193	3.50		10.00	7.80
2004 2008	1 0.0024063	6.00		9.00	7.80
2004 2024	114.8192652	0.50		81.00	0.46
2024 2018	1 0.0164834	0.50		22.00	5.50
2018 2020	1 0.0012023	0.50		2.00	6.00
2020 1718	1 4.4779700	0.50		40.00	3.00
2008 2012	1 0.0040551	9.50		13.00	7.80
2012 2014	1 0.0228440	2.50		38.00	6.00
2014 2016	1 0.0126243	0.50		21.00	6.00
2016 2015	1 1.9210159	0.50		21.00	0.46
2014 2018	1 0.0070851	2.50		11.00	6.00
2018 2262	1 0.0273166	2.50		8.00	3.00
2012 2261	1 0.0273166	3.50		8.00	3.00
2012 2026	1 0.0049909	3.50		16.00	7.80
2026 2029	1 0.0060116	0.50		10.00	6.00
2030 2026	1 0.9147695	0.50		10.00	0.46
2026 2028	1 0.0003119	3.50		1.00	7.80
2028 1721	1 4.4779700	3.50		40.00	3.00
2261 2258	1 0.0734639	3.50		64.00	5.00
2258 2208	1 0.0022957	-2.50		2.00	5.00
2208 2034	1 0.0273166	-2.50		8.00	3.00
2258 2256	1 0.0045915	6.00		4.00	5.00
2256 2255	1 0.0573937	15.00		50.00	5.00
2262 2260	1 0.1228225	2.50		107.00	5.00
2260 2209	1 0.0114787	-2.00		10.00	5.00
2209 2042	1 0.0273166	-2.00		8.00	3.00
2260 2255	1 0.0585416	4.50		51.00	5.00
2255 2253	1 0.0011479	19.50		1.00	5.00
2253 2206	1 0.0011479	-2.00		1.00	5.00
2206 2039	1 0.0341457	-2.00		10.00	3.00
2253 2286	1 0.0746118	21.50		65.00	5.00
2286 2287	1 0.0011479	-3.50		1.00	5.00
2287 2056	1 0.0341457	-3.50		10.00	3.00
2056 1770	1 4.4779700	1.00		40.00	3.00
2254 2285	1 0.0022293	12.00		21.00	11.20
2285 2060	3 0.0029724	12.00	8.00	24.00	11.20
2060 2048	3 7.8670173	3.00	8.00	43.00	0.46
2060 2046	1 0.0018577	9.00		15.00	11.20
2048 2046	1 0.0166711	3.00		34.00	6.70
2046 2059	3 7.5011096	1.50	10.00	41.00	0.46
2046 2051	1 0.0088259	5.00		18.00	6.70
2046 2055	3 8.0499712	4.00	8.00	44.00	0.46
2055 2051	1 0.0127485	4.00		26.00	6.70
2059 2062	1 0.0067888	1.50		5.00	4.45
2062 2051	1 0.0407329	-0.50		30.00	4.45
2062 2064	1 0.0013578	2.00		1.00	4.45

2064 1774	1 4.4779700	1.00		40.00	3.00
2054 2051	1 0.0285130	-3.00		21.00	4.43
2046 2054	1 6.2204323	1.50		34.00	0.46
2051 2291	1 0.0075625	3.00		8.00	5.00
2054 2056	1 0.0013578	4.50		1.00	4.43
2054 2058	1 0.0285130	0.50		21.00	4.43
2058 2061	1 0.0914769	0.50		1.00	0.46
2286 2291	1 0.0218096	25.00		19.00	5.00
2291 2288	1 0.0099294	30.00		20.00	7.00
2288 2289	1 0.0114787	-1.00		10.00	5.00
2289 2064	1 0.0341457	-1.00		10.00	3.00
2288 2290	1 0.0046046	31.00		11.00	7.50
2290 2293	1 0.0016272	1.00		8.00	10.00
2293 1780	1 8.3961938	1.00		75.00	3.00
2290 2275	1 0.0022558	30.00		15.00	11.20
2275 2279	1 0.0005732	30.00		17.00	17.70
79 1	1 0.0000448	60.00		1.00	12.00
1711 2201	1 0.0143886	25.00		150.00	22.30
2201 2211	1 0.0019466	5.00		60.00	18.00
2201 2212	1 0.0028453	20.00		150.00	22.30
2212 2210	1 0.0063985	20.00		100.00	22.30
2650 2655	1 0.0098282	10.00		1.00	3.00
2210 2650	1 0.0098282	10.00		1.00	3.00
2210 2655	1 0.0000640	10.00		1.00	22.30
2655 21	1 0.0014246	20.00		100.00	25.00
21 1	1 0.0000091	20.00		1.00	30.00
1702 1710	1 0.0008058	35.00		9.00	12.00
1710 1711	1 0.0000244	20.00		1.00	19.50
1710 1722	3 1.2919139	15.00	8.00	5.00	0.46
1711 1722	1 0.0002556	-5.00		5.00	15.00
1722 1724	1 0.0056227	10.00		110.00	15.00
1724 1725	3 0.9147695	3.00	2.00	10.00	0.46
1724 1712	1 0.0000511	7.00		1.00	15.00
1712 1725	1 0.0006650	0.50		10.00	13.50
1725 1713	1 0.0016625	3.50		25.00	13.50
1718 1713	1 0.0013038	0.50		6.00	9.00
1713 1715	1 0.0023278	4.00		26.00	12.00
1719 1715	1 0.0023904	0.50		11.00	9.00
1715 1716	1 0.0017906	4.50		20.00	12.00
1721 1716	1 0.0012395	3.50		8.50	10.50
1716 1758	1 0.0147740	8.00		50.00	7.50
1708 1758	1 0.0021731	0.50		10.00	9.00
1712 1714	1 0.0009814	6.50		19.20	15.00
1714 1720	3 9.3306485	3.50	5.00	51.00	0.46
1714 1717	1 0.0000511	3.00		1.00	15.00
1717 1720	1 0.0074368	-0.50		51.00	10.50
1720 1723	1 0.0017033	3.00		45.00	18.00
1717 1723	1 0.0008178	3.50		16.00	15.00
1723 1732	1 0.0017890	6.50		35.00	15.00
1732 1703	1 0.0046662	0.50		32.00	10.50
1732 1735	1 0.0008178	6.00		16.00	15.00
1735 1738	3 1.8295389	2.50	5.00	10.00	0.46
1735 1741	1 0.0000324	3.50		1.00	18.00
1738 1704	1 0.0010445	0.50		10.00	12.00
1738 1741	1 0.0005963	2.00		10.00	15.00

1741 1744	1 0.0005978	5.50		22.50	19.50
1744 1747	3 2.7443084	2.50	5.00	15.00	0.46
1744 1750	1 0.0000324	3.00		1.00	16.00
1747 1705	1 0.0029164	0.50		20.00	10.50
1747 1750	1 0.0021873	2.00		15.00	10.50
1750 1751	1 0.0015941	5.00		60.00	19.50
1751 1756	1 0.0000266	2.00		1.00	19.50
1751 1752	3 1.8295389	3.00	1.00	10.00	0.46
1756 1752	1 0.0008953	-0.50		10.00	12.00
1752 1757	1 0.0013429	2.50		15.00	12.00
1709 1757	1 0.0018925	1.00		8.50	9.00
1757 1758	1 0.0012635	3.50		19.00	13.50
1756 1754	1 0.0006880	2.50		25.00	19.20
1754 1755	1 0.0023274	0.50		30.00	13.50
1754 1762	1 0.0009632	2.00		35.00	19.20
1758 1759	1 0.0026599	12.00		40.00	13.50
1706 1759	1 0.0016298	-1.00		7.50	9.00
1759 1762	1 0.0034706	11.00		55.00	13.80
1762 1763	1 0.0006321	13.00		8.00	12.60
1763 1766	1 0.0021731	0.50		10.00	9.00
1763 1764	1 0.0007111	12.50		9.00	12.60
1764 1767	1 0.0047808	0.50		22.00	9.00
1764 1765	1 0.0045035	12.00		57.00	12.60
1765 1785	1 0.0019752	8.00		15.00	12.60
1785 1786	1 0.0093493	8.00		71.00	12.60
1765 1769	1 0.0033572	4.00		67.00	15.10
1770 1769	1 0.0023904	1.00		11.00	9.00
1769 1768	1 0.0039996	5.00		32.00	10.50
1768 1773	3 0.7318156	1.00	6.00	4.00	0.46
1768 1771	1 0.0000511	1.00		1.00	15.00
1774 1773	1 0.0015212	1.00		7.00	9.00
1773 1771	1 0.0008692	2.00		4.00	9.00
1768 1783	3 3.2931701	3.00	5.00	18.00	0.46
1771 1783	1 0.0011639	3.00		13.00	12.00
1780 1783	1 0.0013124	1.00		9.00	10.50
1783 1786	1 0.0250463	7.00		39.00	5.50
1786 1707	1 0.0003725	15.00		2.00	9.00
2015 2014	1 1.9210159	0.50		21.00	0.46
2029 2030	1 0.0914769	0.50		1.00	0.46
2061 2054	1 1.9210159	0.50		21.00	0.46

0

APPENDIX B.2

**VENTILATION PROGRAM
FAN DATA INPUT FILE**

LEGEND

FAN INPUT FILE

1.	28.4	37.8	44.4	47.2	49.0	51.0	55.
2.	241.	179.	149.	125.	96.	74.	0.
0.	14.2	18.9	21.7	23.6	24.5	25.5	27.5
	110.	85.	70.	60.	45.	35.	0.

→ Fan Flows on Line

→ Fan Pressure on Line

→ Fan Number

→ End of File

FANS.DAT

1.00	9.817	11.044	11.987	12.648	13.498	13.970	14.064
	747.260	622.720	498.180	373.630	249.090	124.540	0.000
	73.000	76.000	75.000	70.000	60.000	50.000	0.000
2.00	6.324	7.174	8.118	8.718	9.439	10.194	10.383
	747.260	622.720	498.180	373.630	249.090	124.540	0.000
	65.000	69.000	70.000	65.000	60.000	55.000	0.000
3.00	6.230	6.890	7.457	7.740	8.306		
	1494.528	1245.440	996.352	747.264	0.000		
	59.000	57.000	52.000	45.000	0.000		
4.00	2.549	2.926	3.209	3.351	3.445	3.587	3.634
	498.176	398.541	298.906	249.088	199.270	99.635	0.000
	68.000	63.000	55.000	50.000	45.000	35.000	0.000
5.00	3.209	3.681	3.964	4.295	4.436	4.531	4.767
	597.811	498.176	398.541	298.906	249.088	199.270	0.000
	68.000	74.000	67.000	57.000	50.000	45.000	0.000
6.00	3.209	3.681	3.964	4.295	4.436	4.531	4.767
	597.811	498.176	398.541	298.906	249.088	199.270	0.000
	68.000	74.000	67.000	57.000	50.000	45.000	0.000
7.00	8.967	10.383	10.855	11.327	11.799	12.271	12.507
	1992.704	1494.528	1245.440	996.352	747.264	498.176	0.000
	75.000	72.000	67.000	63.000	57.000	50.000	0.000
8.00	6.000	7.600	9.100	10.200	10.600	11.700	
	1400.000	1160.000	785.000	515.000	365.000	0.000	
	70.000	73.000	70.000	60.000	50.000	0.000	
9.00	8.850	10.100	11.000	12.100	12.900	13.400	14.200
	2735.000	2360.000	2000.000	1390.000	940.000	710.000	0.000
	75.000	76.000	75.000	70.000	60.000	50.000	0.000
10.00	5.100	6.100	6.600	7.000	7.300	7.700	8.000
	620.000	560.000	500.000	440.000	380.000	310.000	190.000
	73.000	73.000	70.000	68.000	65.000	60.000	50.000
11.00	5.100	6.100	6.600	7.000	7.300	7.700	8.000
	620.000	560.000	500.000	440.000	380.000	310.000	190.000
	73.000	73.000	70.000	68.000	65.000	60.000	50.000
12.00	3.540	4.719	5.003	5.333	5.852	5.899	
	1494.528	996.352	747.264	498.176	249.088	0.000	
	57.000	57.000	55.000	50.000	48.000	0.000	



APPENDIX B.3

**VENTILATION PROGRAM
OUTPUT FILE**

47	2032	2256	1	.01463	8.000	.000	.000
48	2032	2034	1	.01463	3.000	.000	.000
49	2037	2036	1	.01708	3.000	.000	.000
50	2036	2039	1	.00366	1.000	.000	.000
51	2036	2256	1	.03415	1.000	.000	.000
52	2044	2040	1	.09401	6.000	.000	.000
53	2040	2042	1	.00366	3.000	.000	.000
54	2039	1706	1	4.47797	-1.000	.000	.000
55	2042	1709	1	1.09266	1.000	.000	.000
56	2034	1708	1	1.09266	.500	.000	.000
57	2223	2224	1	.00455	10.000	.000	.000
58	2224	2004	3	.00856	10.000	8.000	.000
59	2004	2006	1	.00124	.500	.000	.000
60	2006	1719	1	4.47797	.500	.000	.000
61	2004	2010	3	3.47612	3.500	10.000	.000
62	2010	2008	1	.00312	3.500	.000	.000
63	2004	2008	1	.00241	6.000	.000	.000
64	2004	2024	1	14.81927	.500	.000	.000
65	2024	2018	1	.01648	.500	.000	.000
66	2018	2020	1	.00120	.500	.000	.000
67	2020	1718	1	4.47797	.500	.000	.000
68	2008	2012	1	.00406	9.500	.000	.000
69	2012	2014	1	.02284	2.500	.000	.000
70	2014	2016	1	.01262	.500	.000	.000
71	2016	2015	1	1.92102	.500	.000	.000
72	2014	2018	1	.00709	2.500	.000	.000
73	2018	2262	1	.02732	2.500	.000	.000
74	2012	2261	1	.02732	5.500	.000	.000
75	2012	2026	1	.00499	3.500	.000	.000
76	2026	2029	1	.00601	.500	.000	.000
77	2030	2026	1	.91477	.500	.000	.000
78	2026	2028	1	.00031	3.500	.000	.000
79	2028	1721	1	4.47797	3.500	.000	.000
80	2261	2258	1	.07346	3.500	.000	.000
81	2258	2208	1	.00230	-2.500	.000	.000
82	2208	2034	1	.02732	-2.500	.000	.000
83	2258	2256	1	.00459	6.000	.000	.000
84	2256	2255	1	.05739	15.000	.000	.000
85	2262	2260	1	.12282	2.500	.000	.000
86	2260	2209	1	.01148	-2.000	.000	.000
87	2209	2042	1	.02732	-2.000	.000	.000
88	2260	2255	1	.05854	4.500	.000	.000
89	2255	2253	1	.00115	19.500	.000	.000
90	2253	2206	1	.00115	-2.000	.000	.000
91	2206	2039	1	.03415	-2.000	.000	.000
92	2253	2286	1	.07461	21.500	.000	.000
93	2286	2287	1	.00115	-3.500	.000	.000
94	2287	2056	1	.03415	-3.500	.000	.000
95	2056	1770	1	4.47797	1.000	.000	.000
96	2254	2285	1	.00223	12.000	.000	.000
97	2285	2060	3	.00297	12.000	8.000	.000
98	2060	2048	3	7.86702	3.000	8.000	.000
99	2060	2046	1	.00186	9.000	.000	.000
100	2048	2046	1	.01667	3.000	.000	.000
101	2046	2059	3	7.50111	1.500	10.000	.000

102	2046	2051	1	.00883	5.000	.000	.000
103	2046	2055	3	8.04997	4.000	8.000	.000
104	2055	2051	1	.01275	4.000	.000	.000
105	2059	2062	1	.00679	1.500	.000	.000
106	2062	2051	1	.04073	-.500	.000	.000
107	2062	2064	1	.00136	2.000	.000	.000
108	2064	1774	1	4.47797	1.000	.000	.000
109	2054	2051	1	.02851	-3.000	.000	.000
110	2046	2054	1	6.22043	1.500	.000	.000
111	2051	2291	1	.00756	5.000	.000	.000
112	2054	2056	1	.00136	4.500	.000	.000
113	2054	2058	1	.02851	.500	.000	.000
114	2058	2061	1	.09148	.500	.000	.000
115	2286	2291	1	.02181	25.000	.000	.000
116	2291	2288	1	.00993	30.000	.000	.000
117	2288	2289	1	.01148	-1.000	.000	.000
118	2289	2064	1	.03415	-1.000	.000	.000
119	2288	2290	1	.00460	31.000	.000	.000
120	2290	2293	1	.00163	1.000	.000	.000
121	2293	1780	1	8.39619	1.000	.000	.000
122	2290	2275	1	.00226	30.000	.000	.000
123	2275	2279	1	.00057	30.000	.000	.000
124	79	1	1	.00004	60.000	.000	.000
125	1711	2201	1	.01439	25.000	.000	.000
126	2201	2211	1	.00195	5.000	.000	.000
127	2201	2212	1	.00285	20.000	.000	.000
128	2212	2210	1	.00640	20.000	.000	.000
129	2650	2655	1	.00983	10.000	.000	.000
130	2210	2650	1	.00983	10.000	.000	.000
131	2210	2655	1	.00006	10.000	.000	.000
132	2655	21	1	.00142	20.000	.000	.000
133	21	1	1	.00001	20.000	.000	.000
134	1702	1710	1	.00081	35.000	.000	.000
135	1710	1711	1	.00002	20.000	.000	.000
136	1710	1722	3	1.29191	15.000	8.000	.000
137	1711	1722	1	.00026	-5.000	.000	.000
138	1722	1724	1	.00562	10.000	.000	.000
139	1724	1725	3	.91477	3.000	2.000	.000
140	1724	1712	1	.00005	7.000	.000	.000
141	1712	1725	1	.00066	.500	.000	.000
142	1725	1713	1	.00166	3.500	.000	.000
143	1718	1713	1	.00130	.500	.000	.000
144	1713	1715	1	.00233	4.000	.000	.000
145	1719	1715	1	.00239	.500	.000	.000
146	1715	1716	1	.00179	4.500	.000	.000
147	1721	1716	1	.00124	3.500	.000	.000
148	1716	1758	1	.01477	8.000	.000	.000
149	1708	1758	1	.00217	.500	.000	.000
150	1712	1714	1	.00098	6.500	.000	.000
151	1714	1720	3	9.33065	3.500	5.000	.000
152	1714	1717	1	.00005	3.000	.000	.000
153	1717	1720	1	.00744	-.500	.000	.000
154	1720	1723	1	.00170	3.000	.000	.000
155	1717	1723	1	.00082	3.500	.000	.000
156	1723	1732	1	.00179	6.500	.000	.000

157	1732	1703	1	.00467	.500	.000	.000
158	1732	1735	1	.00082	6.000	.000	.000
159	1735	1738	3	1.82954	2.500	5.000	.000
160	1735	1741	1	.00003	3.500	.000	.000
161	1738	1704	1	.00104	.500	.000	.000
162	1738	1741	1	.00060	2.000	.000	.000
163	1741	1744	1	.00060	5.500	.000	.000
164	1744	1747	3	2.74431	2.500	5.000	.000
165	1744	1750	1	.00003	3.000	.000	.000
166	1747	1705	1	.00292	.500	.000	.000
167	1747	1750	1	.00219	2.000	.000	.000
168	1750	1751	1	.00159	5.000	.000	.000
169	1751	1756	1	.00003	2.000	.000	.000
170	1751	1752	3	1.82954	3.000	1.000	.000
171	1756	1752	1	.00090	-.500	.000	.000
172	1752	1757	1	.00134	2.500	.000	.000
173	1709	1757	1	.00189	1.000	.000	.000
174	1757	1758	1	.00126	3.500	.000	.000
175	1756	1754	1	.00069	2.500	.000	.000
176	1754	1755	1	.00233	.500	.000	.000
177	1754	1762	1	.00096	2.000	.000	.000
178	1758	1759	1	.00266	12.000	.000	.000
179	1706	1759	1	.00163	-1.000	.000	.000
180	1759	1762	1	.00347	11.000	.000	.000
181	1762	1763	1	.00063	13.000	.000	.000
182	1763	1766	1	.00217	.500	.000	.000
183	1763	1764	1	.00071	12.500	.000	.000
184	1764	1767	1	.00478	.500	.000	.000
185	1764	1765	1	.00450	12.000	.000	.000
186	1765	1785	1	.00198	8.000	.000	.000
187	1785	1786	1	.00935	8.000	.000	.000
188	1765	1769	1	.00336	4.000	.000	.000
189	1770	1769	1	.00239	1.000	.000	.000
190	1769	1768	1	.00400	5.000	.000	.000
191	1768	1773	3	.73182	1.000	6.000	.000
192	1768	1771	1	.00005	1.000	.000	.000
193	1774	1773	1	.00152	1.000	.000	.000
194	1773	1771	1	.00087	2.000	.000	.000
195	1768	1783	3	3.29317	3.000	5.000	.000
196	1771	1783	1	.00116	3.000	.000	.000
197	1780	1783	1	.00131	1.000	.000	.000
198	1783	1786	1	.02505	7.000	.000	.000
199	1786	1707	1	.00037	15.000	.000	.000
200	2015	2014	1	1.92102	.500	.000	.000
201	2029	2030	1	.09148	.500	.000	.000
202	2061	2054	1	1.92102	.500	.000	.000

CIRCUIT CHARACTERISTICS

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      NODES          148
    BRANCHES: TOTAL 202
          FAN        19
        REGULATED    0
          FIXED       2
  
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FAN CHARACTERISTIC CURVES

CURVE #	3.	FLOW	PRESSURE	EFFICIENCY
		6.230	1494.528	59.00
		6.890	1245.440	57.00
		7.457	996.352	52.00
		7.740	747.264	45.00
		8.306	.000	.00

CURVE #	4.	FLOW	PRESSURE	EFFICIENCY
		2.549	498.176	68.00
		2.926	398.541	63.00
		3.209	298.906	55.00
		3.351	249.088	50.00
		3.445	199.270	45.00
		3.587	99.635	35.00
		3.634	.000	.00

CURVE #	5.	FLOW	PRESSURE	EFFICIENCY
		3.209	597.811	68.00
		3.681	498.176	74.00
		3.964	398.541	67.00
		4.295	298.906	57.00
		4.436	249.088	50.00
		4.531	199.270	45.00
		4.767	.000	.00

CURVE #	6.	FLOW	PRESSURE	EFFICIENCY
		3.209	597.811	68.00
		3.681	498.176	74.00
		3.964	398.541	67.00
		4.295	298.906	57.00
		4.436	249.088	50.00
		4.531	199.270	45.00
		4.767	.000	.00

CURVE #	7.	FLOW	PRESSURE	EFFICIENCY
		8.967	1992.704	75.00

10.383	1494.528	72.00
10.855	1245.440	67.00
11.327	996.352	63.00
11.799	747.264	57.00
12.271	498.176	50.00
12.507	1.000	.00

CURVE # 8.	FLOW	PRESSURE	EFFICIENCY
	6.000	1400.000	70.00
	7.600	1160.000	73.00
	9.100	785.000	70.00
	10.200	515.000	60.00
	10.600	365.000	50.00
	11.700	.000	.00

CURVE # 9.	FLOW	PRESSURE	EFFICIENCY
	8.850	2735.000	75.00
	10.100	2360.000	76.00
	11.000	2000.000	75.00
	12.100	1390.000	70.00
	12.900	940.000	60.00
	13.400	710.000	50.00
	14.200	.000	1.00

CURVE # 10.	FLOW	PRESSURE	EFFICIENCY
	5.100	620.000	73.00
	6.100	560.000	73.00
	6.600	500.000	70.00
	7.000	440.000	68.00

7.300	380.000	63.00
7.700	310.000	60.00
8.000	190.000	50.00

CURVE # 11.	FLOW	PRESSURE	EFFICIENCY
	5.100	620.000	73.00
	6.100	560.000	73.00
	6.600	500.000	70.00
	7.000	440.000	68.00
	7.300	380.000	63.00
	7.700	310.000	60.00
	8.000	190.000	50.00

CURVE # 12.	FLOW	PRESSURE	EFFICIENCY
	3.540	1494.528	57.00
	4.719	996.352	57.00
	5.003	747.264	53.00
	5.333	498.176	50.00
	5.852	249.088	48.00
	5.899	.000	.00

FAN CURVES IN :

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.
- 8.
- 9.
- 10.
- 11.
- 12.

40	2252	2031	14.144	1.200	-1.188	49.637	.005	48.449	3	.00594	.000	9.00
41	2031	2033	6.779	1.200	-.060	.000	.000	-.060	1	.00130	.000	.00
42	2031	2044	7.365	1.200	-1032.002	1036.921	2.280	4.919	3	19.02720	.000	3.00
43	2033	2032	1.729	1.200	-.378	.000	.000	-.378	1	.12634	.000	.00
44	2033	2037	5.050	1.200	-711.679	711.730	1.078	.051	3	27.90534	.000	12.00
45	2036	2032	-1.209	1.200	.024	.000	.000	.024	1	.01669	.000	.00
46	2032	2040	-2.563	1.200	.314	.000	.000	.314	1	.04780	.000	.00
47	2032	2256	1.232	1.200	-.022	.000	.000	-.022	1	.01463	.000	.00
48	2032	2034	1.851	1.200	-.050	.000	.000	-.050	1	.01463	.000	.00
49	2037	2036	5.050	1.200	-.436	.000	.001	-.436	1	.01708	.000	.00
50	2036	2039	6.138	1.200	-.138	.000	.000	-.138	1	.00366	.000	.00
51	2036	2256	.121	1.200	-.001	.000	.000	-.001	1	.03415	.000	.00
52	2044	2040	7.365	1.200	-5.099	.000	.011	-5.099	1	.09401	.000	.00
53	2040	2042	4.802	1.200	-.084	.000	.000	-.084	1	.00366	.000	.00
54	2039	1706	2.351	1.200	-24.747	.000	.017	-24.747	1	4.47797	.000	.00
55	2042	1709	3.113	1.200	-10.591	.000	.010	-10.591	1	1.09266	.000	.00
56	2034	1708	3.077	1.200	-10.344	.000	.010	-10.344	1	1.09266	.000	.00
57	2223	2224	11.956	1.200	-.650	.000	.002	-.650	1	.00455	.000	.00
58	2224	2004	11.956	1.200	-1.223	.000	.004	-1.223	3	.00856	.000	8.00
59	2004	2006	2.028	1.200	-.005	.000	.000	-.005	1	.00124	.000	.00
60	2006	1719	2.028	1.200	-18.412	.000	.011	-18.412	1	4.47797	.000	.00
61	2004	2010	7.928	1.200	-218.502	218.684	.520	.182	3	3.47612	.000	10.00
62	2010	2008	7.928	1.200	-.196	.000	.000	-.196	1	.00312	.000	.00
63	2004	2008	1.785	1.200	-.008	.000	.000	-.008	1	.00241	.000	.00
64	2004	2024	.215	1.200	-.687	.000	.000	-.687	1	14.81927	.000	.00
65	2024	2018	.215	1.200	-.001	.000	.000	-.001	1	.01648	.000	.00
66	2018	2020	1.766	1.200	-.004	.000	.000	-.004	1	.00120	.000	.00
67	2020	1718	1.766	1.200	-13.973	.000	.007	-13.973	1	4.47797	.000	.00
68	2008	2012	9.713	1.200	-.383	.000	.001	-.383	1	.00406	.000	.00
69	2012	2014	3.403	1.200	-.265	.000	.000	-.265	1	.02284	.000	.00
70	2014	2016	.000	1.200	.000	.000	.000	.000	1	.01262	.000	.00
71	2016	2015	.000	1.200	.000	.000	.000	.000	1	1.92102	.000	.00
72	2014	2018	3.403	1.200	-.082	.000	.000	-.082	1	.00709	.000	.00
73	2018	2262	1.852	1.200	-.094	.000	.000	-.094	1	.02732	.000	.00
74	2012	2261	3.267	1.200	-.292	.000	.000	-.292	1	.02732	.000	.00
75	2012	2026	3.043	1.200	-.046	.000	.000	-.046	1	.00499	.000	.00
76	2026	2029	.000	1.200	.000	.000	.000	.000	1	.00601	.000	.00
77	2030	2026	.000	1.200	.000	.000	.000	.000	1	.91477	.000	.00
78	2026	2028	3.043	1.200	-.003	.000	.000	-.003	1	.00031	.000	.00
79	2028	1721	3.043	1.200	-41.458	.000	.038	-41.458	1	4.47797	.000	.00
80	2261	2258	3.267	1.200	-.784	.000	.001	-.784	1	.07346	.000	.00
81	2258	2208	1.225	1.200	-.003	.000	.000	-.003	1	.00230	.000	.00
82	2208	2034	1.225	1.200	-.041	.000	.000	-.041	1	.02732	.000	.00
83	2258	2256	2.042	1.200	-.019	.000	.000	-.019	1	.00459	.000	.00
84	2256	2255	3.395	1.200	-.662	.000	.001	-.662	1	.05739	.000	.00
85	2262	2260	1.852	1.200	-.421	.000	.000	-.421	1	.12282	.000	.00
86	2260	2209	-1.688	1.200	.033	.000	.000	.033	1	.01148	.000	.00
87	2209	2042	-1.688	1.200	.078	.000	.000	.078	1	.02732	.000	.00
88	2260	2255	3.540	1.200	-.734	.000	.001	-.734	1	.05854	.000	.00
89	2255	2253	6.935	1.200	-.055	.000	.000	-.055	1	.00115	.000	.00

90	2253	2206	-3.787	1.200	.016	.000	.000	.016	1	.00115	.000	.00
91	2206	2039	-3.787	1.200	.490	.000	.001	.490	1	.03415	.000	.00
92	2253	2286	10.722	1.200	-8.578	.000	.028	-8.578	1	.07461	.000	.00
93	2286	2287	3.672	1.200	-.015	.000	.000	-.015	1	.00115	.000	.00
94	2287	2056	3.672	1.200	-.460	.000	.001	-.460	1	.03415	.000	.00
95	2056	1770	.799	1.200	-2.861	.000	.001	-2.861	1	4.47797	.000	.00
96	2254	2285	11.571	1.200	-.298	.000	.001	-.298	1	.00223	.000	.00
97	2285	2060	11.571	1.200	-.398	42.801	.001	42.403	3	.00297	.000	8.00
98	2060	2048	9.437	1.200	-700.686	702.163	1.984	1.476	3	7.86702	.000	8.00
99	2060	2046	2.134	1.200	-.008	.000	.000	-.008	1	.00186	.000	.00
100	2048	2046	9.437	1.200	-1.485	.000	.004	-1.485	1	.01667	.000	.00
101	2046	2059	7.234	1.200	-392.560	393.162	.852	.602	3	7.50111	.000	10.00
102	2046	2051	-4.836	1.200	.206	.000	.000	.206	1	.00883	.000	.00
103	2046	2055	9.397	1.200	-710.815	712.145	2.004	1.329	3	8.04997	.000	8.00
104	2055	2051	9.397	1.200	-1.126	.000	.003	-1.126	1	.01275	.000	.00
105	2059	2062	7.234	1.200	-.355	.000	.001	-.355	1	.00679	.000	.00
106	2062	2051	.404	1.200	-.007	.000	.000	-.007	1	.04073	.000	.00
107	2062	2064	6.830	1.200	-.063	.000	.000	-.063	1	.00136	.000	.00
108	2064	1774	-.596	1.200	1.589	.000	.000	1.589	1	4.47797	.000	.00
109	2054	2051	2.649	1.200	-.200	.000	.000	-.200	1	.02851	.000	.00
110	2046	2054	-.224	1.200	.311	.000	.000	.311	1	6.22043	.000	.00
111	2051	2291	7.614	1.200	-.438	.000	.001	-.438	1	.00756	.000	.00
112	2054	2056	-2.873	1.200	.011	.000	.000	.011	1	.00136	.000	.00
113	2054	2058	.000	1.200	.000	.000	.000	.000	1	.02851	.000	.00
114	2058	2061	.000	1.200	.000	.000	.000	.000	1	.09148	.000	.00
115	2286	2291	7.050	1.200	-1.084	.000	.002	-1.084	1	.02181	.000	.00
116	2291	2288	14.664	1.200	-2.135	.000	.009	-2.135	1	.00993	.000	.00
117	2288	2289	-7.425	1.200	.633	.000	.001	.633	1	.01148	.000	.00
118	2289	2064	-7.425	1.200	1.883	.000	.004	1.883	1	.03415	.000	.00
119	2288	2290	22.090	1.200	-2.247	.000	.015	-2.247	1	.00460	.000	.00
120	2290	2293	-.706	1.200	.001	.000	.000	.001	1	.00163	.000	.00
121	2293	1780	-.706	1.200	4.189	.000	.001	4.189	1	8.39619	.000	.00
122	2290	2275	22.796	1.200	-1.172	.000	.008	-1.172	1	.00226	.000	.00
123	2275	2279	22.796	1.200	-.298	.000	.002	-.298	1	.00057	.000	.00
124	79	1	57.982	1.200	-.151	.000	.003	-.151	1	.00004	.000	.00
125	1711	2201	28.412	1.200	-11.615	.000	.099	-11.615	1	.01439	.000	.00
126	2201	2211	6.394	1.200	-.080	.000	.000	-.080	1	.00195	.000	.00
127	2201	2212	22.018	1.200	-1.379	.000	.009	-1.379	1	.00285	.000	.00
128	2212	2210	22.018	1.200	-3.102	.000	.020	-3.102	1	.00640	.000	.00
129	2650	2655	1.080	1.200	-.011	.000	.000	-.011	1	.00983	.000	.00
130	2210	2650	1.080	1.200	-.011	.000	.000	-.011	1	.00983	.000	.00
131	2210	2655	20.937	1.200	-.028	.000	.000	-.028	1	.00006	.000	.00
132	2655	21	22.018	1.200	-.691	.000	.005	-.691	1	.00142	.000	.00
133	21	1	22.018	1.200	-.004	.000	.000	-.004	1	.00001	.000	.00
134	1702	1710	30.514	1.200	-.750	.000	.007	-.750	1	.00081	.000	.00
135	1710	1711	16.458	1.200	-.007	.000	.000	-.007	1	.00002	.000	.00
136	1710	1722	14.057	1.200	-255.277	.000	1.077	-255.277	3	1.29191	.000	8.00
137	1711	1722	-11.955	1.200	.037	.000	.000	.037	1	.00026	.000	.00
138	1722	1724	2.102	1.200	-.025	.000	.000	-.025	1	.00562	.000	.00
139	1724	1725	10.237	1.200	-95.871	95.971	.294	.100	3	.91477	.000	2.00

140	1724	1712	-8.135	1.200	.003	.000	.000	.003	1	.00005	.000	.00
141	1712	1725	-12.957	1.200	.112	.000	.000	.112	1	.00066	.000	.00
142	1725	1713	-2.719	1.200	.012	.000	.000	.012	1	.00166	.000	.00
143	1718	1713	1.766	1.200	-.004	.000	.000	-.004	1	.00130	.000	.00
144	1713	1715	-.953	1.200	.002	.000	.000	.002	1	.00233	.000	.00
145	1719	1715	2.028	1.200	-.010	.000	.000	-.010	1	.00239	.000	.00
146	1715	1716	1.075	1.200	-.002	.000	.000	-.002	1	.00179	.000	.00
147	1721	1716	3.043	1.200	-.011	.000	.000	-.011	1	.00124	.000	.00
148	1716	1758	4.118	1.200	-.250	.000	.000	-.250	1	.01477	.000	.00
149	1708	1758	3.077	1.200	-.021	.000	.000	-.021	1	.00217	.000	.00
150	1712	1714	4.822	1.200	-.023	.000	.000	-.023	1	.00098	.000	.00
151	1714	1720	4.539	1.200	-192.260	192.269	.262	.010	3	9.33065	.000	5.00
152	1714	1717	.282	1.200	.000	.000	.000	.000	1	.00005	.000	.00
153	1717	1720	-1.410	1.200	.015	.000	.000	.015	1	.00744	.000	.00
154	1720	1723	3.129	1.200	-.017	.000	.000	-.017	1	.00170	.000	.00
155	1717	1723	1.692	1.200	-.002	.000	.000	-.002	1	.00082	.000	.00
156	1723	1732	4.822	1.200	-.042	.000	.000	-.042	1	.00179	.000	.00
157	1732	1703	-.859	1.200	.003	.000	.000	.003	1	.00467	.000	.00
158	1732	1735	5.680	1.200	-.026	.000	.000	-.026	1	.00082	.000	.00
159	1735	1738	4.056	1.200	-30.095	370.915	.037	340.820	3	1.82954	.000	5.00
160	1735	1741	1.624	1.200	.000	.000	.000	.000	1	.00003	.000	.00
161	1738	1704	-.607	1.200	.000	.000	.000	.000	1	.00104	.000	.00
162	1738	1741	4.663	1.200	-.013	.000	.000	-.013	1	.00060	.000	.00
163	1741	1744	6.287	1.200	-.024	.000	.000	-.024	1	.00060	.000	.00
164	1744	1747	2.650	1.200	-19.274	597.811	.015	578.536	3	2.74431	.000	5.00
165	1744	1750	3.637	1.200	.000	.000	.000	.000	1	.00003	.000	.00
166	1747	1705	.556	1.200	-.001	.000	.000	-.001	1	.00292	.000	.00
167	1747	1750	2.094	1.200	-.010	.000	.000	-.010	1	.00219	.000	.00
168	1750	1751	5.731	1.200	-.052	.000	.000	-.052	1	.00159	.000	.00
169	1751	1756	-7.333	1.200	.001	.000	.000	.001	1	.00003	.000	.00
170	1751	1752	13.065	1.200	-312.273	312.592	1.224	.319	3	1.82954	.000	1.00
171	1756	1752	-16.747	1.200	.251	.000	.001	.251	1	.00090	.000	.00
172	1752	1757	-3.682	1.200	.018	.000	.000	.018	1	.00134	.000	.00
173	1709	1757	3.113	1.200	-.018	.000	.000	-.018	1	.00189	.000	.00
174	1757	1752	-.569	1.200	.000	.000	.000	.000	1	.00126	.000	.00
175	1756	1754	9.413	1.200	-.061	.000	.000	-.061	1	.00069	.000	.00
176	1754	1755	1.191	1.200	-.003	.000	.000	-.003	1	.00233	.000	.00
177	1754	1762	8.223	1.200	-.065	.000	.000	-.065	1	.00096	.000	.00
178	1758	1759	6.626	1.200	-.117	.000	.000	-.117	1	.00266	.000	.00
179	1706	1759	2.351	1.200	-.009	.000	.000	-.009	1	.00163	.000	.00
180	1759	1762	8.977	1.200	-.280	.000	.001	-.280	1	.00347	.000	.00
181	1762	1763	17.199	1.200	-.187	.000	.001	-.187	1	.00063	.000	.00
182	1763	1766	1.170	1.200	-.003	.000	.000	-.003	1	.00217	.000	.00
183	1763	1764	16.030	1.200	-.183	.000	.001	-.183	1	.00071	.000	.00
184	1764	1767	1.249	1.200	-.007	.000	.000	-.007	1	.00478	.000	.00
185	1764	1765	14.780	1.200	-.984	.000	.004	-.984	1	.00450	.000	.00
186	1765	1785	7.807	1.200	-.120	.000	.000	-.120	1	.00198	.000	.00
187	1785	1786	7.807	1.200	-.570	.000	.001	-.570	1	.00935	.000	.00
188	1765	1769	6.973	1.200	-.163	.000	.000	-.163	1	.00336	.000	.00
189	1770	1769	.799	1.200	-.002	.000	.000	-.002	1	.00239	.000	.00

190	1769	1768	7.772	1.200	-.242	.000	.001	-.242	1	.00400	.000	.00
191	1768	1773	40.899	1.200	-1224.105	.000	15.019	-1224.105	3	.73182	.000	6.00
192	1768	1771	-37.808	1.200	.073	.000	.001	.073	1	.00005	.000	.00
193	1774	1773	-.596	1.200	.001	.000	.000	.001	1	.00152	.000	.00
194	1773	1771	40.303	1.200	-1.412	.000	.017	-1.412	1	.00087	.000	.00
195	1768	1783	4.681	1.200	-72.173	72.249	.101	.076	3	3.29317	.000	5.00
196	1771	1783	2.495	1.200	-.007	.000	.000	-.007	1	.00116	.000	.00
197	1780	1783	-.706	1.200	.001	.000	.000	.001	1	.00131	.000	.00
198	1783	1786	6.470	1.200	-1.049	.000	.002	-1.049	1	.02505	.000	.00
199	1786	1707	14.277	1.200	-.076	.000	.000	-.076	1	.00037	.000	.00
200	2015	2014	.000	1.200	.000	.000	.000	.000	1	1.92102	.000	.00
201	2029	2030	.000	1.200	.000	.000	.000	.000	1	.09148	.000	.00
202	2061	2054	.000	1.200	.000	.000	.000	.000	1	1.92102	.000	.00

OTOTAL FAN POWER REQUIREMENT : 29.41 HP
CONVERGENCE INDEX:*****

1

BRANCHES WITH MORE THAN 10% FLOW CHANGE

BR. NO.	INI. NODE	FINAL NODE	NEW FLOW	OLD FLOW	CHANGE
4	2202	1702	30.514	35.000	-4.486
5	2211	2223	55.880	50.000	5.880
7	2225	2226	7.846	6.000	1.846
8	2226	2227	7.846	6.000	1.846
9	2227	2229	7.846	6.000	1.846
10	1703	2203	-.859	.500	-1.359
11	2203	2229	-.859	.500	-1.359
13	1704	2204	-.607	.500	-1.107
14	2204	2231	-.607	.500	-1.107
16	1705	2205	.556	.500	.056
17	2205	2235	.556	.500	.056
19	1755	2242	1.191	.500	.691
20	2242	2236	1.191	.500	.691
22	1766	2244	1.170	.500	.670
23	2244	2238	1.170	.500	.670
25	1767	2246	1.249	.500	.749
26	2246	2240	1.249	.500	.749
27	2240	2245	10.546	9.000	1.546
28	2245	2249	10.546	9.000	1.546
30	2243	2247	10.363	6.000	4.363
32	2247	2279	10.263	5.500	4.763
33	2249	2281	10.646	9.500	1.146
39	2254	2252	14.144	16.000	-1.856
40	2252	2031	14.144	16.000	-1.856
41	2031	2033	6.779	10.000	-3.221
42	2031	2044	7.365	6.000	1.365
43	2033	2032	1.729	7.000	-5.271
44	2033	2037	5.050	3.000	2.050
45	2036	2032	-1.209	1.000	-2.209
46	2032	2040	-2.563	-3.000	.437

47	2032	2256	1.232	8.000	-6.768
48	2032	2034	1.851	3.000	-1.149
49	2037	2036	5.050	3.000	2.050
50	2036	2039	6.138	1.000	5.138
51	2036	2256	.121	1.000	-.879
52	2044	2040	7.365	6.000	1.365
53	2040	2042	4.802	3.000	1.802
54	2039	1706	2.351	-1.000	3.351
55	2042	1709	3.113	1.000	2.113
56	2034	1708	3.077	.500	2.577
57	2223	2224	11.956	10.000	1.956
58	2224	2004	11.956	10.000	1.956
59	2004	2006	2.028	.500	1.528
60	2006	1719	2.028	.500	1.528
61	2004	2010	7.928	3.500	4.428
62	2010	2008	7.928	3.500	4.428
63	2004	2008	1.785	6.000	-4.215
64	2004	2024	.215	.500	-.285
65	2024	2018	.215	.500	-.285
66	2018	2020	1.766	.500	1.266
67	2020	1718	1.766	.500	1.266
69	2012	2014	3.403	2.500	.903
70	2014	2016	.000	.500	-.500
71	2016	2015	.000	.500	-.500
72	2014	2018	3.403	2.500	.903
73	2018	2262	1.852	2.500	-.648
75	2012	2026	3.043	3.500	-.457
76	2026	2029	.000	.500	-.500
77	2030	2026	.000	.500	-.500
78	2026	2028	3.043	3.500	-.457
79	2028	1721	3.043	3.500	-.457
81	2258	2208	1.225	-2.500	3.725
82	2208	2034	1.225	-2.500	3.725
83	2258	2256	2.042	6.000	-3.958
84	2256	2255	3.395	15.000	-11.605
85	2262	2260	1.852	2.500	-.648
86	2260	2209	-1.688	-2.000	.312
87	2209	2042	-1.688	-2.000	.312
88	2260	2255	3.540	4.500	-.960
89	2255	2253	6.935	19.500	-12.565
90	2253	2206	-3.787	-2.000	-1.787
91	2206	2039	-3.787	-2.000	-1.787
92	2253	2286	10.722	21.500	-10.778
93	2286	2287	3.672	-3.500	7.172
94	2287	2056	3.672	-3.500	7.172
95	2056	1770	.799	1.000	-.201
98	2060	2048	9.437	3.000	6.437
99	2060	2046	2.134	9.000	-6.866
100	2048	2046	9.437	3.000	6.437
101	2046	2059	7.234	1.500	5.734
102	2046	2051	-4.836	5.000	-9.836
103	2046	2055	9.397	4.000	5.397
104	2055	2051	9.397	4.000	5.397
105	2059	2062	7.234	1.500	5.734
106	2062	2051	.404	-.500	.904

107	2062	2064	6.830	2.000	4.830
108	2064	1774	-.596	1.000	-1.596
109	2054	2051	2.649	-3.000	5.649
110	2046	2054	-.224	1.500	-1.724
111	2051	2291	7.614	5.000	2.614
112	2054	2056	-2.873	4.500	-7.373
113	2054	2058	.000	.500	-.500
114	2058	2061	.000	.500	-.500
115	2286	2291	7.050	25.000	-17.950
116	2291	2288	14.664	30.000	-15.336
117	2288	2289	-7.425	-1.000	-6.425
118	2289	2064	-7.425	-1.000	-6.425
119	2288	2290	22.090	31.000	-8.910
120	2290	2293	-.706	1.000	-1.706
121	2293	1780	-.706	1.000	-1.706
122	2290	2275	22.796	30.000	-7.204
123	2275	2279	22.796	30.000	-7.204
125	1711	2201	28.412	25.000	3.412
126	2201	2211	6.394	5.000	1.394
127	2201	2212	22.018	20.000	2.018
128	2212	2210	22.018	20.000	2.018
129	2650	2655	1.080	10.000	-8.919
130	2210	2650	1.080	10.000	-8.919
131	2210	2655	20.937	10.000	10.937
132	2655	21	22.018	20.000	2.018
133	21	1	22.018	20.000	2.018
134	1702	1710	30.514	35.000	-4.486
135	1710	1711	16.458	20.000	-3.542
137	1711	1722	-11.955	-5.000	-6.955
138	1722	1724	2.102	10.000	-7.898
139	1724	1725	10.237	3.000	7.237
140	1724	1712	-8.135	7.000	-15.135
141	1712	1725	-12.957	.500	-13.457
142	1725	1713	-2.719	3.500	-6.219
143	1718	1713	1.766	.500	1.266
144	1713	1715	-.953	4.000	-4.953
145	1719	1715	2.026	.500	1.526
146	1715	1716	1.075	4.500	-3.425
147	1721	1716	3.043	3.500	-.457
148	1716	1758	4.118	8.000	-3.882
149	1708	1758	3.077	.500	2.577
150	1712	1714	4.822	6.500	-1.678
151	1714	1720	4.539	3.500	1.039
152	1714	1717	.282	3.000	-2.718
153	1717	1720	-1.410	-.500	-.910
155	1717	1723	1.692	3.500	-1.808
156	1723	1732	4.822	6.500	-1.678
157	1732	1703	-.859	.500	-1.359
159	1735	1738	4.056	2.500	1.556
160	1735	1741	1.624	3.500	-1.876
161	1738	1704	-.607	.500	-1.107
162	1738	1741	4.663	2.000	2.663
163	1741	1750	6.287	5.500	.787
165	1744	1750	3.637	3.000	.637
166	1747	1705	.556	.500	.056

168	1750	1751	5.731	5.000	.731
169	1751	1756	-7.333	2.000	-9.333
170	1751	1752	13.065	3.000	10.065
171	1756	1752	-16.747	-.500	-16.247
172	1752	1757	-3.682	2.500	-6.182
173	1709	1757	3.113	1.000	2.113
174	1757	1758	-.569	3.500	-4.068
175	1756	1754	9.413	2.500	6.913
176	1754	1755	1.191	.500	.691
177	1754	1762	8.223	2.000	6.223
178	1758	1759	6.626	12.000	-5.374
179	1706	1759	2.351	-1.000	3.351
180	1759	1762	8.977	11.000	-2.023
181	1762	1763	17.199	13.000	4.199
182	1763	1766	1.170	.500	.670
183	1763	1764	16.030	12.500	3.530
184	1764	1767	1.249	.500	.749
185	1764	1765	14.780	12.000	2.780
188	1765	1769	6.973	4.000	2.973
189	1770	1769	.799	1.000	-.201
190	1769	1768	7.772	5.000	2.772
191	1768	1773	40.899	1.000	39.899
192	1768	1771	-37.808	1.000	-38.808
193	1774	1773	-.596	1.000	-1.596
194	1773	1771	40.303	2.000	38.303
195	1768	1783	4.681	3.000	1.681
196	1771	1783	2.495	3.000	-.505
197	1780	1783	-.706	1.000	-1.706
200	2015	2014	.000	.500	-.500
201	2029	2030	.000	.500	-.500
202	2061	2054	.000	.500	-.500

1

NODE PRESSURES RELATIVE TO ATMOSPHERIC

NODE	PRESSURE	NODE	PRESSURE	NODE	PRESSURE	NODE	PRESSURE	NODE	PRESSURE
1	.000	2	19.612	21	.004	79	.151	1702	16.782
1703	-239.335	1704	101.456	1705	339.147	1706	.372	1707	-241.685
1708	14.887	1709	14.919	1710	16.032	1711	16.025	1712	-239.267
1713	-239.158	1714	-239.289	1715	-239.156	1716	-239.158	1717	-239.289
1718	-23.815	1719	-27.568	1720	-239.280	1721	-51.055	1722	-239.245
1723	-239.297	1724	-239.270	1725	-239.170	1732	-239.338	1735	-239.365
1738	101.455	1741	-239.365	1744	-239.388	1747	339.148	1750	-239.389
1751	-239.441	1752	-239.122	1754	-239.501	1755	-239.504	1756	-239.440
1757	-239.104	1758	-239.408	1759	-239.525	1762	-239.566	1763	-239.753
1764	-239.935	1765	-240.919	1766	-239.756	1767	-239.943	1768	-241.324
1769	-241.082	1770	12.627	1771	-241.251	1773	-1465.429	1774	21.351
1780	19.154	1783	-241.248	1785	-241.040	1786	-241.609	2004	-9.151
2006	-9.156	2008	-9.165	2010	-8.969	2012	-9.548	2014	-9.812
2015	-9.812	2016	-9.812	2018	-9.838	2020	-9.842	2024	-9.837
2026	-9.594	2028	-9.597	2029	-9.594	2030	-9.594	2031	25.718
2032	25.281	2033	25.659	2034	25.231	2036	25.256	2037	25.709
2039	25.119	2040	25.595	2042	25.510	2044	30.638	2046	19.579
2048	21.064	2051	19.785	2054	19.985	2055	20.908	2056	15.488

*****CONTROL CODE # 98*****

APPENDIX B.4

**RADIATION PROGRAM
MINE CHARACTERISTICS
INPUT FILE**

LEGEND

Line	Node	Code	Flow (m ³ /sec)	Area (m ²)	Length (m)	Output from VENTPROG (not needed)	Balanced Flows (m ³ /sec)	Output from VENTPROG (not needed)	Final Node	Initial Node	End of Data
10	1	3	0.00000	49.21	0.0	0.00000	0.00000				
20	1	3	0.00000	49.83	0.0	0.00000	0.00000				
10	11	1	0.01300	-49.21	0.0	100.00000	10.00000				
11	12	1	0.01300	-19.75	0.0	100.00000	10.00000				
1	40	1	0.00000	33.26	0.0	0.00000	0.00000				
40	41	1	0.01700	33.26	0.0	300.00000	15.00000				
41	42	1	0.01700	11.24	0.0	300.00000	15.00000				
1	30	1	0.00000	65.77	0.0	0.00000	0.00000				
30	31	1	0.00300	65.77	0.0	100.00000	24.00000				
31	32	1	0.00300	31.60	0.0	100.00000	24.00000				
20	21	1	0.01300	-49.83	0.0	100.00000	10.00000				
21	22	1	0.01300	-23.09	0.0	100.00000	10.00000				
31	41	1	0.00500	34.17	0.0	50.00000	12.00000				
32	42	1	0.00500	31.60	0.0	50.00000	12.00000				
41	21	1	0.05000	26.73	0.0	500.00000	12.00000				
41	11	1	0.05000	29.45	0.0	500.00000	12.00000				
42	22	1	0.05000	23.09	0.0	500.00000	12.00000				
42	51	1	0.02000	19.75	0.0	200.00000	12.00000				
51	53	1	0.01000	45.33	0.0	100.00000	12.00000				
53	12	1	0.02000	19.75	0.0	200.00000	12.00000				
53	52	1	0.01000	25.57	0.0	100.00000	12.00000				
52	51	3	0.01000	25.57	0.0	100.00000	12.00000				

RADIN

			50	0			
1	2	1	1.0	80.00	0.0	1.000	28.000
2	2202	1	1.0	80.00	0.0	75.000	28.000
2202	2211	1	1.0	49.54	0.0	10.000	20.000
2202	1702	1	1.0	30.46	0.0	50.000	28.000
2211	2223	1	1.0	55.88	0.0	100.000	16.600
2223	2225	1	1.0	43.93	0.0	63.000	16.600
2225	2226	1	1.0	7.85	0.0	40.000	0.460
2226	2227	1	1.0	7.85	0.0	30.000	16.000
2227	2229	1	1.0	7.85	0.0	40.000	12.000
1703	2203	1	1.0	-0.92	0.0	50.000	3.000
2203	2229	1	1.0	-0.92	0.0	2.000	12.000
2229	2231	1	1.0	6.93	0.0	15.000	12.000
1704	2204	1	1.0	-0.77	0.0	50.000	3.000
2204	2231	1	1.0	-0.77	0.0	15.000	12.000
2231	2235	1	1.0	6.17	0.0	25.000	12.000
1705	2205	1	1.0	0.60	0.0	50.000	3.000
2205	2235	1	1.0	0.60	0.0	5.000	11.500
2235	2236	1	1.0	6.76	0.0	100.000	11.000
1755	2242	1	1.0	1.24	0.0	50.000	3.000
2242	2236	1	1.0	1.24	0.0	4.000	10.000
2236	2238	1	1.0	8.00	0.0	20.000	9.500
1766	2244	1	1.0	1.24	0.0	50.000	3.000
2244	2238	1	1.0	1.24	0.0	15.000	9.000
2238	2240	1	1.0	9.24	0.0	15.000	9.000
1767	2246	1	1.0	1.30	0.0	50.000	3.000
2246	2240	1	1.0	1.30	0.0	3.000	9.000
2240	2245	1	1.0	10.55	0.0	60.000	8.230
2245	2249	1	1.0	10.55	0.0	25.000	13.200
2225	2243	1	1.0	36.08	0.0	213.900	18.560
2243	2247	1	1.0	10.36	0.0	10.000	18.560
2247	2249	1	1.0	0.10	0.0	12.000	17.700
2247	2279	1	1.0	10.26	0.0	105.000	0.460
2249	2281	1	1.0	10.65	0.0	71.000	17.700
1707	2207	1	1.0	14.31	0.0	50.000	8.160
2207	2281	1	1.0	14.31	0.0	4.000	15.000
2281	2279	1	1.0	24.96	0.0	15.000	17.700
2279	79	1	1.0	57.96	0.0	75.000	12.000
2243	2254	1	1.0	25.72	0.0	66.840	15.480
2254	2252	1	1.0	14.15	0.0	11.500	11.800
2252	2031	1	1.0	14.15	0.0	64.000	11.800
2031	2033	1	1.0	6.78	0.0	10.000	11.000
2031	2044	1	1.0	7.37	0.0	104.000	0.460
2033	2032	1	1.0	1.73	0.0	37.000	3.000
2033	2037	1	1.0	5.05	0.0	108.000	0.460
2036	2032	1	1.0	-1.24	0.0	41.400	7.240
2032	2040	1	1.0	-2.57	0.0	14.000	3.000
2032	2056	1	1.0	1.22	0.0	4.000	3.000
2032	2034	1	1.0	1.84	0.0	4.000	3.000
2037	2036	1	1.0	5.05	0.0	27.300	7.240
2036	2039	1	1.0	6.16	0.0	1.000	3.000
2036	2256	1	1.0	0.13	0.0	10.000	3.000
2044	2040	1	1.0	7.37	0.0	72.200	4.530
2040	2042	1	1.0	4.79	0.0	1.000	3.000

2039 1706	1	1.0	2.36	0.0	40.000	3.000
2042 1709	1	1.0	3.09	0.0	40.000	3.000
2034 1708	1	1.0	3.05	0.0	40.000	3.000
2223 2224	1	1.0	11.96	0.0	17.000	7.800
2224 2004	1	1.0	11.96	0.0	32.000	7.800
2004 2006	1	1.0	2.04	0.0	4.000	9.000
2006 1719	1	1.0	2.04	0.0	40.000	3.000
2004 2010	1	1.0	7.93	0.0	19.000	0.460
2010 2008	1	1.0	7.93	0.0	10.000	7.800
2004 2008	1	1.0	1.78	0.0	9.000	7.800
2004 2024	1	1.0	0.22	0.0	81.000	0.460
2024 2018	1	1.0	0.22	0.0	22.000	5.500
2018 2020	1	1.0	1.77	0.0	2.000	6.000
2020 1718	1	1.0	1.77	0.0	40.000	3.000
2008 2012	1	1.0	9.71	0.0	13.000	7.800
2012 2014	1	1.0	3.40	0.0	38.000	6.000
2014 2016	1	1.0	0.01	0.0	21.000	6.000
2016 2015	1	1.0	0.01	0.0	21.000	0.460
2014 2018	1	1.0	3.40	0.0	11.000	6.000
2018 2262	1	1.0	1.85	0.0	8.000	3.000
2012 2261	1	1.0	3.27	0.0	8.000	3.000
2012 2026	1	1.0	3.03	0.0	16.000	7.800
2026 2029	1	1.0	0.01	0.0	10.000	6.000
2030 2026	1	1.0	0.01	0.0	10.000	0.460
2026 2028	1	1.0	3.03	0.0	1.000	7.800
2028 1721	1	1.0	3.03	0.0	40.000	3.000
2261 2258	1	1.0	3.27	0.0	64.000	5.000
2258 2208	1	1.0	1.21	0.0	2.000	5.000
2208 2034	1	1.0	1.21	0.0	8.000	3.000
2258 2256	1	1.0	2.06	0.0	4.000	5.000
2256 2255	1	1.0	3.42	0.0	50.000	5.000
2262 2260	1	1.0	1.85	0.0	107.000	5.000
2260 2209	1	1.0	-1.70	0.0	10.000	5.000
2209 2042	1	1.0	-1.70	0.0	8.000	3.000
2260 2255	1	1.0	3.55	0.0	51.000	5.000
2255 2253	1	1.0	6.97	0.0	1.000	5.000
2253 2206	1	1.0	-3.80	0.0	1.000	5.000
2206 2039	1	1.0	-3.80	0.0	10.000	3.000
2253 2286	1	1.0	10.76	0.0	65.000	5.000
2286 2287	1	1.0	3.70	0.0	1.000	5.000
2287 2056	1	1.0	3.70	0.0	10.000	3.000
2056 1770	1	1.0	0.71	0.0	40.000	3.000
2254 2285	1	1.0	11.57	0.0	21.000	11.200
2285 2060	1	1.0	11.57	0.0	24.000	11.200
2060 2048	1	1.0	9.44	0.0	43.000	0.460
2060 2046	1	1.0	2.13	0.0	15.000	11.200
2048 2046	1	1.0	9.44	0.0	34.000	6.700
2046 2059	1	1.0	7.23	0.0	41.000	0.460
2046 2051	1	1.0	-4.83	0.0	18.000	6.700
2046 2055	1	1.0	9.40	0.0	44.000	0.460
2055 2051	1	1.0	9.40	0.0	26.000	6.700
2059 2062	1	1.0	7.23	0.0	5.000	4.450
2062 2051	1	1.0	0.07	0.0	30.000	4.450
2062 2064	1	1.0	7.16	0.0	1.000	4.450
2064 1774	1	1.0	-0.13	0.0	40.000	3.000

2054 2051	1	1.0	2.76	0.0	21.000	4.450
2046 2054	1	1.0	-0.23	0.0	34.000	0.460
2051 2291	1	1.0	7.40	0.0	8.000	5.000
2054 2056	1	1.0	-2.99	0.0	1.000	4.450
2054 2058	1	1.0	0.01	0.0	21.000	4.450
2058 2061	1	1.0	0.01	0.0	1.000	0.460
2286 2291	1	1.0	7.06	0.0	19.000	5.000
2291 2288	1	1.0	14.46	0.0	20.000	7.000
2288 2289	1	1.0	-7.30	0.0	10.000	5.000
2289 2064	1	1.0	-7.30	0.0	10.000	3.000
2288 2290	1	1.0	21.76	0.0	11.000	7.500
2290 2291	1	1.0	-0.98	0.0	8.000	10.000
2291 1780	1	1.0	-0.98	0.0	75.000	3.000
2290 2275	1	1.0	22.75	0.0	15.000	11.200
2275 2279	1	1.0	22.75	0.0	17.000	17.700
79 1	1	1.0	57.96	0.0	1.000	12.000
1711 2201	1	1.0	28.38	0.0	150.000	22.300
2201 2211	1	1.0	6.35	0.0	60.000	18.000
2201 2212	1	1.0	22.04	0.0	150.000	22.300
2212 2210	1	1.0	22.04	0.0	100.000	22.300
2650 2655	1	1.0	1.09	0.0	1.000	3.000
2210 2650	1	1.0	1.09	0.0	1.000	3.000
2210 2655	1	1.0	20.95	0.0	1.000	22.300
2655 21	1	1.0	22.04	0.0	100.000	25.000
21 1	1	1.0	22.04	0.0	1.000	30.000
1702 1710	1	1.0	30.46	0.0	9.000	12.000
1710 1711	1	1.0	16.41	0.0	1.000	19.500
1710 1722	1	1.0	14.06	0.0	5.000	0.460
1711 1722	1	1.0	-11.98	0.0	5.000	15.000
1722 1724	1	1.0	2.08	0.0	110.000	15.000
1724 1725	1	1.0	10.24	0.0	10.000	0.460
1724 1712	1	1.0	-8.16	0.0	1.000	15.000
1712 1725	1	1.0	-13.00	0.0	10.000	13.500
1725 1713	1	1.0	-2.76	0.0	25.000	13.500
1718 1713	1	1.0	1.77	0.0	6.000	9.000
1713 1715	1	1.0	-0.99	0.0	26.000	12.000
1719 1715	1	1.0	2.04	0.0	11.000	9.000
1715 1716	1	1.0	1.05	0.0	20.000	12.000
1721 1716	1	1.0	3.03	0.0	8.500	10.500
1716 1758	1	1.0	4.08	0.0	50.000	7.500
1708 1758	1	1.0	3.05	0.0	10.000	9.000
1712 1714	1	1.0	4.84	0.0	19.200	15.000
1714 1720	1	1.0	4.54	0.0	51.000	0.460
1714 1717	1	1.0	0.30	0.0	1.000	15.000
1717 1720	1	1.0	-1.41	0.0	51.000	10.500
1720 1723	1	1.0	3.13	0.0	45.000	18.000
1717 1723	1	1.0	1.71	0.0	16.000	15.000
1723 1732	1	1.0	4.84	0.0	35.000	15.000
1732 1703	1	1.0	-0.92	0.0	32.000	10.500
1732 1735	1	1.0	5.76	0.0	16.000	15.000
1735 1738	1	1.0	5.14	0.0	10.000	0.460
1735 1741	1	1.0	0.62	0.0	1.000	18.000
1738 1704	1	1.0	-0.77	0.0	10.000	12.000
1738 1741	1	1.0	5.90	0.0	10.000	15.000
1741 1744	1	1.0	6.52	0.0	22.500	19.500

1744 1747	1	1.0	2.65	0.0	15.000	0.460
1744 1750	1	1.0	3.87	0.0	1.000	18.000
1747 1705	1	1.0	0.60	0.0	20.000	10.500
1747 1750	1	1.0	2.05	0.0	15.000	10.500
1750 1751	1	1.0	5.92	0.0	60.000	19.500
1751 1756	1	1.0	-7.14	0.0	1.000	19.500
1751 1752	1	1.0	13.07	0.0	10.000	0.460
1756 1752	1	1.0	-16.67	0.0	10.000	12.000
1752 1757	1	1.0	-3.61	0.0	15.000	12.000
1709 1757	1	1.0	3.09	0.0	8.500	9.000
1757 1758	1	1.0	-0.52	0.0	19.000	13.500
1756 1754	1	1.0	9.53	0.0	25.000	19.200
1754 1755	1	1.0	1.24	0.0	30.000	13.500
1754 1762	1	1.0	8.29	0.0	35.000	19.200
1758 1759	1	1.0	6.62	0.0	40.000	13.500
1706 1759	1	1.0	2.36	0.0	7.500	9.000
1759 1762	1	1.0	8.98	0.0	55.000	13.800
1762 1763	1	1.0	17.27	0.0	8.000	12.600
1763 1766	1	1.0	1.24	0.0	10.000	9.000
1763 1764	1	1.0	16.03	0.0	9.000	12.600
1764 1767	1	1.0	1.30	0.0	22.000	9.000
1764 1765	1	1.0	14.72	0.0	57.000	12.600
1765 1785	1	1.0	8.00	0.0	15.000	12.600
1785 1786	1	1.0	8.00	0.0	71.000	12.600
1765 1769	1	1.0	6.73	0.0	67.000	15.100
1770 1769	1	1.0	0.71	0.0	11.000	9.000
1769 1768	1	1.0	7.43	0.0	32.000	10.500
1768 1773	1	1.0	19.85	0.0	4.000	0.460
1768 1771	1	1.0	-17.10	0.0	1.000	15.000
1774 1773	1	1.0	-0.13	0.0	7.000	9.000
1773 1771	1	1.0	19.72	0.0	4.000	9.000
1768 1783	1	1.0	4.68	0.0	18.000	0.460
1771 1783	1	1.0	2.62	0.0	13.000	12.000
1780 1783	1	1.0	-0.98	0.0	9.000	10.500
1783 1786	1	1.0	6.31	0.0	39.000	5.500
1786 1707	1	1.0	14.31	0.0	2.000	9.000
2015 2014	1	1.0	0.01	0.0	21.000	0.460
2029 2030	1	1.0	0.01	0.0	1.000	0.460
2061 2054	1	1.0	0.01	0.0	21.000	0.460

0

APPENDIX B.5

**RADIATION PROGRAM
EMANATION CHARACTERISTICS
INPUT FILE**

EMANATION CHARACTERISTICS FILE

LEGEND

	1	number 1 initializes all radon and radon daughter levels in surface air intakes to zero
	0	
10.	11.	
3		end of node initialization
500.	.46	
400.	.25	
400.	.72	initial and final node numbers
11.	12.	number of emanating components
3		
500.	.46	number of emanating components and
400.	.25	
400.	.72	3 emanating components area (m ²)
20.	21.	emanation rate (Bq/m ² .s)
3		
500.	.46	
400.	.25	
400.	.72	initial and final node numbers
21.	22.	etc.
3		
500.	.46	
400.	.25	
400.	.72	
30.	31.	
3		
800.	.46	
600.	.25	
600.	.72	
31.	32.	
3		
800.	.46	
600.	.25	
600.	.72	
40.	41.	
1		
4800.	.5	
41.	42.	
1		
4800.	.5	
31.	41.	
3		
300.	.46	
200.	.25	
200.	.72	
32.	42.	
3		
300.	.46	
200.	.25	
200.	.72	
42.	22.	
3		

EMANAT

1	
0	
1	2
1	
21.2	0.667
2	2202
1	
1590.0	0.667
2202	2211
1	
179.0	0.667
2202	1702
1	
1060.0	0.667
2211	2223
1	
1630.0	0.667
2223	2225
1	
1026.9	0.667
2225	2226
1	
96.0	0.000
2226	2227
1	
480.0	5.333
2227	2229
1	
556.0	5.333
1703	2203
1	
355.0	2.444
2203	2229
1	
27.8	5.333
2229	2231
1	
208.5	5.333
1704	2204
1	
355.0	2.444
2204	2231
1	
208.5	5.333
2231	2235
1	
347.5	5.333
1705	2205
1	
355.0	2.444
2205	2235
1	
68.0	5.333

2235	2236
1	
1330.0	5.333
1755	2242
1	
355.0	2.444
2242	2236
1	
51.6	5.333
2236	2238
1	
252.0	5.333
1766	2244
1	
355.0	2.444
2244	2238
1	
183.0	5.333
2238	2240
1	
183.0	5.333
1767	2246
1	
355.0	2.444
2246	2240
1	
36.6	5.333
2240	2245
1	
702.0	5.333
2245	2249
1	
362.5	0.667
2225	2243
1	
3679.1	0.667
2243	2247
1	
172.0	0.667
2247	2249
1	
201.6	0.667
2247	2279
1	
252.0	0.000
2249	2281
1	
1192.8	0.667
1707	2207
1	
585.0	0.667
2207	2281
1	
62.0	0.667
2281	2279

1		
252.0	0.667	
2279	79	
1		
1042.5	0.667	
2243	2254	
1		
1049.4	2.074	
2254	2252	
1		
157.5	5.333	
2252	2031	
1		
876.8	5.333	
2031	2033	
1		
133.0	5.333	
2031	2044	
1		
249.6	0.000	
2033	2032	
1		
262.7	5.333	
2033	2037	
1		
259.2	0.000	
2036	2032	
1		
455.4	5.333	
2032	2040	
1		
99.4	5.333	
2032	2056	
1		
28.4	2.444	
2032	2034	
1		
28.4	5.333	
2037	2036	
1		
300.3	65.519	
2036	2039	
1		
7.1	5.333	
2036	2256	
1		
71.0	2.444	
2044	2040	
1		
628.1	65.519	
2040	2042	
1		
7.1	5.333	
2039	1706	
1		

284.0	2.444
2042	1709
1	
284.0	2.444
2034	1708
1	
284.0	2.444
2223	2224
1	
193.8	0.667
2224	2004
1	
364.8	5.333
2004	2006
1	
48.8	5.333
2006	1719
1	
284.0	2.444
2004	2010
1	
45.6	0.000
2010	2008
1	
114.0	65.519
2004	2008
1	
102.6	5.333
2004	2024
1	
194.4	0.000
2024	2018
1	
211.2	5.333
2018	2020
1	
20.0	5.333
2020	1718
1	
284.0	2.444
2008	2012
1	
148.2	5.333
2012	2014
1	
380.0	5.333
2014	2016
1	
210.0	5.333
2016	2015
1	
50.4	0.000
2014	2018
1	
110.0	5.333

2018	2262
1	
56.8	2.444
2012	2261
1	
56.8	2.444
2012	2026
1	
182.4	5.333
2026	2029
1	
100.0	5.333
2030	2026
1	
24.0	0.000
2026	2028
1	
11.4	5.333
2028	1721
1	
284.0	2.444
2261	2258
1	
582.4	5.333
2258	2208
1	
18.2	5.333
2208	2034
1	
56.8	2.444
2258	2256
1	
36.4	5.333
2256	2255
1	
455.0	5.333
2262	2260
1	
973.7	5.333
2260	2209
1	
91.0	5.333
2209	2042
1	
56.8	2.444
2260	2255
1	
464.1	5.333
2255	2253
1	
9.1	5.333
2253	2206
1	
9.1	5.333
2206	2039

1		
71.0	2.444	
2253	2286	
1		
591.5	5.333	
2286	2287	
1		
9.1	5.333	
2287	2056	
1		
71.0	2.444	
2056	1770	
1		
284.0	2.444	
2254	2285	
1		
281.4	5.333	
2285	2060	
1		
371.6	5.333	
2060	2048	
1		
103.2	0.000	
2060	2046	
1		
201.0	5.333	
2048	2046	
1		
360.4	65.519	
2046	2059	
1		
98.4	0.000	
2046	2051	
1		
190.8	5.333	
2046	2055	
1		
105.6	0.000	
2055	2051	
1		
275.6	65.519	
2059	2062	
1		
43.0	65.519	
2062	2051	
1		
258.0	5.333	
2062	2064	
1		
8.6	5.333	
2064	1774	
1		
284.0	2.444	
2054	2051	
1		

180.6	5.333
2046	2054
1	
81.6	0.000
2051	2291
1	
72.8	2.444
2054	2056
1	
8.6	5.333
2054	2058
1	
180.6	65.519
2058	2061
1	
2.4	0.000
2286	2291
1	
172.9	5.333
2291	2288
1	
216.0	5.333
2288	2289
1	
91.0	5.333
2289	2064
1	
71.0	2.444
2288	2290
1	
123.2	5.333
2290	2293
1	
103.2	5.333
2291	1780
1	
532.5	2.444
2290	2275
1	
201.0	5.333
2275	2279
1	
285.6	0.667
79	1
1	
13.9	0.667
1711	2201
1	
2835.0	0.667
2201	2211
1	
1020.0	0.667
2201	2212
1	
2835.0	0.667

2212	2210
1	
1890.0	0.667
2650	2655
1	
7.1	0.667
2210	2650
1	
7.1	0.667
2210	2655
1	
18.9	0.667
2655	21
1	
2000.0	0.667
21	1
1	
22.0	0.667
1702	1710
1	
125.1	0.667
1710	1711
1	
17.7	0.667
1710	1722
1	
12.0	0.000
1711	1722
1	
77.5	0.667
1722	1724
1	
1705.0	0.667
1724	1725
1	
24.0	0.000
1724	1712
1	
15.5	0.667
1712	1725
1	
147.0	0.667
1725	1713
1	
367.5	0.667
1718	1713
1	
73.2	2.444
1713	1715
1	
361.4	2.444
1719	1715
1	
134.2	2.444
1715	1716

1		
278.0	2.444	
1721	1716	
1		
110.5	2.444	
1716	1758	
1		
560.0	2.444	
1708	1758	
1		
122.0	2.444	
1712	1714	
1		
297.6	0.667	
1714	1720	
1		
122.4	0.000	
1714	1717	
1		
15.5	0.667	
1717	1720	
1		
663.0	0.667	
1720	1723	
1		
765.0	0.667	
1717	1723	
1		
248.0	0.667	
1723	1732	
1		
542.5	0.667	
1732	1703	
1		
416.0	0.667	
1732	1735	
1		
248.0	0.667	
1735	1738	
1		
24.0	0.000	
1735	1741	
1		
17.0	0.667	
1738	1704	
1		
139.0	0.667	
1738	1741	
1		
155.0	0.667	
1741	1744	
1		
398.3	0.667	
1744	1747	
1		

36.0	0.000
1744	1750
1	
17.0	0.667
1747	1705
1	
260.0	0.667
1747	1750
1	
195.0	0.667
1750	1751
1	
1062.0	0.667
1751	1756
1	
17.7	0.667
1751	1752
1	
24.0	0.000
1756	1752
1	
139.0	2.444
1752	1757
1	
208.5	2.444
1709	1757
1	
106.3	2.444
1757	1758
1	
279.3	2.444
1756	1754
1	
437.5	0.667
1754	1755
1	
441.0	0.667
1754	1762
1	
612.5	0.667
1758	1759
1	
588.0	2.444
1706	1759
1	
91.5	2.444
1759	1762
1	
819.5	2.444
1762	1763
1	
113.6	0.667
1763	1766
1	
122.0	0.667

1763	1764
1	
127.8	0.667
1764	1767
1	
268.4	0.667
1764	1765
1	
809.4	0.667
1765	1785
1	
213.0	0.667
1785	1786
1	
1008.2	0.667
1765	1769
1	
1038.5	0.667
1770	1769
1	
134.2	2.444
1769	1768
1	
416.0	2.444
1768	1773
1	
9.6	0.000
1768	1771
1	
15.5	2.444
1774	1773
1	
85.4	2.444
1773	1771
1	
48.8	2.444
1768	1783
1	
43.2	0.000
1771	1783
1	
180.7	2.444
1780	1783
1	
117.0	2.444
1783	1786
1	
374.4	2.444
1786	1707
1	
24.4	0.667
2015	2014
1	
50.4	0.000
2029	2030

1		
2.4	0.000	
2061	2054	
1		
50.4	0.000	
0		

APPENDIX B.6

RADIATION PROGRAM

OUTPUT FILE

RADOUT

AIRWAYS		Flowrate	Length	Cross Sectional Area
		Q(M3/SEC)	X(M)	A(M2)
1	2	80.0	1.0	28.0
2	2202	80.0	75.0	28.0
2202	2211	49.5	10.0	20.0
2202	1702	30.5	50.0	28.0
2211	2223	55.9	100.0	16.6
2223	2225	43.9	63.0	16.6
2225	2226	7.8	40.0	0.5
2226	2227	7.8	30.0	16.0
2227	2229	7.8	40.0	12.0
2203	1703	0.9	50.0	3.0
2229	2203	0.9	2.0	12.0
2229	2231	6.9	15.0	12.0
2204	1704	0.8	50.0	3.0
2231	2204	0.8	15.0	12.0
2231	2235	6.2	25.0	12.0
1705	2205	0.6	50.0	3.0
2205	2235	0.6	5.0	11.5
2235	2236	6.8	100.0	11.0
1755	2242	1.2	50.0	3.0
2242	2236	1.2	4.0	10.0
2236	2238	8.0	20.0	9.5
1766	2244	1.2	50.0	3.0
2244	2238	1.2	15.0	9.0
2238	2240	9.2	15.0	9.0
1767	2246	1.3	50.0	3.0
2246	2240	1.3	3.0	9.0
2240	2245	10.6	60.0	8.2
2245	2249	10.6	25.0	13.2
2225	2243	36.1	213.9	18.6
2243	2247	10.4	10.0	18.6
2247	2249	0.1	12.0	17.7
2247	2279	10.3	105.0	0.5
2249	2281	10.6	71.0	17.7
1707	2207	14.3	50.0	8.2
2207	2281	14.3	4.0	15.0
2281	2279	25.0	15.0	17.7
2279	79	58.0	75.0	12.0
2243	2254	25.7	66.8	15.5
2254	2252	14.1	11.5	11.8
2252	2031	14.1	64.0	11.8
2031	2033	6.8	10.0	11.0
2031	2044	7.4	104.0	0.5
2033	2032	1.7	37.0	3.0
2033	2037	5.1	108.0	0.5
2032	2036	1.2	41.4	7.2
2040	2032	2.6	14.0	3.0
2032	2056	1.2	4.0	3.0
2032	2034	1.8	4.0	3.0
2037	2036	5.1	27.3	7.2
2036	2039	6.2	1.0	3.0
2036	2256	0.1	10.0	3.0

2044	2040	7.4	72.2	4.5
2040	2042	4.8	1.0	3.0
2039	1706	2.4	40.0	3.0
2042	1709	3.1	40.0	3.0
2034	1708	3.0	40.0	3.0
2223	2224	12.0	17.0	7.8
2224	2004	12.0	32.0	7.8
2004	2006	2.0	4.0	9.0
2006	1719	2.0	40.0	3.0
2004	2010	7.9	19.0	0.5
2010	2008	7.9	10.0	7.8
2004	2008	1.8	9.0	7.8
2004	2024	0.2	81.0	0.5
2024	2018	0.2	22.0	5.5
2018	2020	1.8	2.0	6.0
2020	1718	1.8	40.0	3.0
2008	2012	9.7	13.0	7.8
2012	2014	3.4	38.0	6.0
2014	2016	0.0	21.0	6.0
2016	2015	0.0	21.0	0.5
2014	2018	3.4	11.0	6.0
2018	2262	1.9	8.0	3.0
2012	2261	3.3	8.0	3.0
2012	2026	3.0	16.0	7.8
2026	2029	0.0	10.0	6.0
2030	2026	0.0	10.0	0.5
2026	2028	3.0	1.0	7.8
2028	1721	3.0	40.0	3.0
2261	2258	3.3	64.0	5.0
2258	2208	1.2	2.0	5.0
2208	2034	1.2	8.0	3.0
2258	2256	2.1	4.0	5.0
2256	2255	3.4	50.0	5.0
2262	2260	1.9	107.0	5.0
2209	2260	1.7	10.0	5.0
2042	2209	1.7	8.0	3.0
2260	2255	3.5	51.0	5.0
2255	2253	7.0	1.0	5.0
2206	2253	3.8	1.0	5.0
2039	2206	3.8	10.0	3.0
2253	2286	10.8	65.0	5.0
2286	2287	3.7	1.0	5.0
2287	2056	3.7	10.0	3.0
2056	1770	0.7	40.0	3.0
2254	2285	11.6	21.0	11.2
2285	2060	11.6	24.0	11.2
2060	2048	9.4	43.0	0.5
2060	2046	2.1	15.0	11.2
2048	2046	9.4	34.0	6.7
2046	2059	7.2	41.0	0.5
2051	2046	4.8	18.0	6.7
2046	2055	9.4	44.0	0.5
2055	2051	9.4	26.0	6.7
2059	2062	7.2	5.0	4.4
2062	2051	0.1	30.0	4.4

2062	2064	7.2	1.0	4.4
1774	2064	0.1	40.0	3.0
2054	2051	2.8	21.0	4.4
2054	2046	0.2	34.0	0.5
2051	2291	7.4	8.0	5.0
2056	2054	3.0	1.0	4.4
2054	2058	0.0	21.0	4.4
2058	2061	0.0	1.0	0.5
2286	2291	7.1	19.0	5.0
2291	2288	14.5	20.0	7.0
2289	2288	7.3	10.0	5.0
2064	2289	7.3	10.0	3.0
2288	2290	21.8	11.0	7.5
2291	2290	1.0	8.0	10.0
1780	2291	1.0	75.0	3.0
2290	2275	22.8	15.0	11.2
2275	2279	22.8	17.0	17.7
1711	2201	28.4	150.0	22.3
2201	2211	6.3	60.0	18.0
2201	2212	22.0	150.0	22.3
2212	2210	22.0	100.0	22.3
2650	2655	1.1	1.0	3.0
2210	2650	1.1	1.0	3.0
2210	2655	21.0	1.0	22.3
2655	21	22.0	100.0	25.0
1702	1710	30.5	9.0	12.0
1710	1711	16.4	1.0	19.5
1710	1722	14.1	5.0	0.5
1722	1711	12.0	5.0	15.0
1722	1724	2.1	110.0	15.0
1724	1725	10.2	10.0	0.5
1712	1724	8.2	1.0	15.0
1725	1712	13.0	10.0	13.5
1713	1725	2.8	25.0	13.5
1718	1713	1.8	6.0	9.0
1715	1713	1.0	26.0	12.0
1719	1715	2.0	11.0	9.0
1715	1716	1.0	20.0	12.0
1721	1716	3.0	8.5	10.5
1716	1758	4.1	50.0	7.5
1708	1758	3.0	10.0	9.0
1712	1714	4.8	19.2	15.0
1714	1720	4.5	51.0	0.5
1714	1717	0.3	1.0	15.0
1720	1717	1.4	51.0	10.5
1720	1723	3.1	45.0	18.0
1717	1723	1.7	16.0	15.0
1723	1732	4.8	35.0	15.0
1703	1732	0.9	32.0	10.5
1732	1735	5.8	16.0	15.0
1735	1738	5.1	10.0	0.5
1735	1741	0.6	1.0	18.0
1704	1738	0.8	10.0	12.0
1738	1741	5.9	10.0	15.0
1741	1744	6.5	22.5	19.5

1744	1747	2.7	15.0	0.5
1744	1750	3.9	1.0	18.0
1747	1705	0.6	20.0	10.5
1747	1750	2.0	15.0	10.5
1750	1751	5.9	60.0	19.5
1756	1751	7.1	1.0	19.5
1751	1752	13.1	10.0	0.5
1752	1756	16.7	10.0	12.0
1757	1752	3.6	15.0	12.0
1709	1757	3.1	8.5	9.0
1758	1757	0.5	19.0	13.5
1756	1754	9.5	25.0	19.2
1754	1755	1.2	30.0	13.5
1754	1762	8.3	35.0	19.2
1758	1759	6.6	40.0	13.5
1706	1759	2.4	7.5	9.0
1759	1762	9.0	55.0	13.8
1762	1763	17.3	8.0	12.6
1763	1766	1.2	10.0	9.0
1763	1764	16.0	9.0	12.6
1764	1767	1.3	22.0	9.0
1764	1765	14.7	57.0	12.6
1765	1785	8.0	15.0	12.6
1785	1786	8.0	71.0	12.6
1765	1769	6.7	67.0	15.1
1770	1769	0.7	11.0	9.0
1769	1768	7.4	32.0	10.5
1768	1773	19.9	4.0	0.5
1771	1768	17.1	1.0	15.0
1773	1774	0.1	7.0	9.0
1773	1771	19.7	4.0	9.0
1768	1783	4.7	18.0	0.5
1771	1783	2.6	13.0	12.0
1783	1780	1.0	9.0	10.5
1783	1786	6.3	39.0	5.5
1786	1707	14.3	2.0	9.0
2015	2014	0.0	21.0	0.5
2029	2030	0.0	1.0	0.5
2061	2054	0.0	21.0	0.5

AIRWAYS		Surface AREA (M2)	Emanation EM RATE (BQ/(M2.SEC))
1	2		
		21.2	0.667
2	2202		
		1590.0	0.667
2202	2211		
		179.0	0.667
2202	1702		
		1060.0	0.667

2211	2223	1630.0	0.667
2223	2225	1026.9	0.667
2225	2226	96.0	0.000
2226	2227	480.0	5.333
2227	2229	556.0	5.333
2203	1703	355.0	2.444
2229	2203	27.8	5.333
2229	2231	208.5	5.333
2204	1704	355.0	2.444
2231	2204	208.5	5.333
2231	2235	347.5	5.333
1705	2205	355.0	2.444
2205	2235	68.0	5.333
2235	2236	1330.0	5.333
1755	2242	355.0	2.444
2242	2236	51.6	5.333
2236	2238	252.0	5.333
1766	2244	355.0	2.444
2244	2238	183.0	5.333
2238	2240	183.0	5.333
1767	2246	355.0	2.444
2246	2240	36.6	5.333
2240	2245	702.0	5.333
2245	2249	362.5	0.667
2225	2243	3679.1	0.667
2243	2247	172.0	0.667
2247	2249	201.6	0.667
2247	2279		

		252.0	0.000
2249	2281		
		1192.8	0.667
1707	2207		
		585.0	0.667
2207	2281		
		62.0	0.667
2281	2279		
		252.0	0.667
2279	79		
		1042.5	0.667
2243	2254		
		1049.4	2.074
2254	2252		
		157.5	5.333
2252	2031		
		876.8	5.333
2031	2033		
		133.0	5.333
2031	2044		
		249.6	0.000
2033	2032		
		262.7	5.333
2033	2037		
		259.2	0.000
2032	2036		
		455.4	5.333
2040	2032		
		99.4	5.333
2032	2056		
		28.4	2.444
2032	2034		
		28.4	5.333
2037	2036		
		300.3	65.519
2036	2039		
		7.1	5.333
2036	2256		
		71.0	2.444
2044	2040		
		628.1	65.519
2040	2042		
		7.1	5.333
2039	1706		
		284.0	2.444
2042	1709		
		284.0	2.444
2034	1708		
		284.0	2.444
2223	2224		
		193.8	0.667
2224	2004		
		364.8	5.333
2004	2006		
		48.8	5.333

2006	1719		
		284.0	2.444
2004	2010		
		45.6	0.000
2010	2008		
		114.0	65.519
2004	2008		
		102.6	5.333
2004	2024		
		194.4	0.000
2024	2018		
		211.2	5.333
2018	2020		
		20.0	5.333
2020	1718		
		284.0	2.444
2008	2012		
		148.2	5.333
2012	2014		
		380.0	5.333
2014	2016		
		210.0	5.333
2016	2015		
		50.4	0.000
2014	2018		
		110.0	5.333
2018	2262		
		56.8	2.444
2012	2261		
		56.8	2.444
2012	2026		
		182.4	5.333
2026	2029		
		100.0	5.333
2030	2026		
		24.0	0.000
2026	2028		
		11.4	5.333
2028	1721		
		284.0	2.444
2261	2258		
		582.4	5.333
2258	2208		
		18.2	5.333
2208	2034		
		56.8	2.444
2258	2256		
		36.4	5.333
2256	2255		
		455.0	5.333
2262	2260		
		973.7	5.333
2209	2260		
		91.0	5.333
2042	2209		

2260	2255	56.8	2.444
2255	2253	464.1	5.333
2206	2253	9.1	5.333
2039	2206	9.1	5.333
2253	2286	71.0	2.444
2286	2287	591.5	5.333
2287	2056	9.1	5.333
2056	1770	71.0	2.444
2254	2285	284.0	2.444
2285	2060	281.4	5.333
2060	2048	321.6	5.333
2060	2046	103.2	0.000
2048	2046	201.0	5.333
2046	2059	360.4	65.519
2051	2046	98.4	0.000
2046	2055	190.8	5.333
2055	2051	105.6	0.000
2059	2062	275.6	65.519
2062	2051	43.0	65.519
2062	2064	258.0	5.333
1774	2064	8.6	5.333
2054	2051	284.0	2.444
2054	2046	180.6	5.333
2051	2291	81.6	0.000
2056	2054	72.8	2.444
2054	2058	8.6	5.333
2058	2061	180.6	65.519
		2.4	0.000

2286	2291	172.9	5.333
2291	2288	216.0	5.333
2289	2288	91.0	5.333
2064	2289	71.0	2.444
2288	2290	123.2	5.333
1780	2291	532.5	2.444
2290	2275	201.0	5.333
2275	2279	285.6	0.667
1711	2201	2835.0	0.667
2201	2211	1020.0	0.667
2201	2212	2835.0	0.667
2212	2210	1890.0	0.667
2650	2655	7.1	0.667
2210	2650	7.1	0.667
2210	2655	18.9	0.667
2655	21	2000.0	0.667
1702	1710	125.1	0.667
1710	1711	17.7	0.667
1710	1722	12.0	0.000
1722	1711	77.5	0.667
1722	1724	1705.0	0.667
1724	1725	24.0	0.000
1712	1724	15.5	0.667
1725	1712	147.0	0.667
1713	1725	367.5	0.667
1718	1713	73.2	2.444
1715	1713	361.4	2.444
1719	1715		

1715	1716	134.2	2.444
1721	1716	278.0	2.444
1716	1758	110.5	2.444
1708	1758	560.0	2.444
1712	1714	122.0	2.444
1714	1720	297.6	0.667
1714	1717	122.4	0.000
1720	1717	15.5	0.667
1720	1723	663.0	0.667
1717	1723	765.0	0.667
1723	1732	248.0	0.667
1703	1732	542.5	0.667
1732	1735	416.0	0.667
1735	1738	248.0	0.667
1735	1741	24.0	0.000
1704	1738	17.0	0.667
1738	1741	139.0	0.667
1741	1744	155.0	0.667
1744	1747	398.3	0.667
1744	1750	36.0	0.000
1747	1705	17.0	0.667
1747	1750	260.0	0.667
1750	1751	195.0	0.667
1756	1751	1062.0	0.667
1751	1752	17.7	0.667
1752	1756	24.0	0.000
1757	1752	139.0	2.444
		208.5	2.444

1709	1757	106.3	2.444
1758	1757	279.3	2.444
1756	1754	437.5	0.667
1754	1755	441.0	0.667
1754	1762	612.5	0.667
1758	1759	588.0	2.444
1706	1759	91.5	2.444
1759	1762	819.5	2.444
1762	1763	113.6	0.667
1763	1766	122.0	0.667
1763	1764	127.8	0.667
1764	1767	268.4	0.667
1764	1765	809.4	0.667
1765	1785	213.0	0.667
1785	1786	1008.2	0.667
1765	1769	1038.5	0.667
1770	1769	134.2	2.444
1769	1768	416.0	2.444
1768	1773	9.6	0.000
1771	1768	15.5	2.444
1773	1774	85.4	2.444
1773	1771	48.8	2.444
1768	1783	43.2	0.000
1771	1783	180.7	2.444
1783	1780	117.0	2.444
1783	1786	374.4	2.444
1786	1707	24.4	0.667
2015	2014		

		50.4	0.000
2029	2030		
		2.4	0.000
2061	2054		
		50.4	0.000

** COMPOUND RECIRCULATION LOOP:
171217251724

LOOP CANCELED

** COMPOUND RECIRCULATION LOOP:
171217251724

LOOP CANCELED

** SIMPLE RECIRCULATION LOOP:
203020292026
NO. OF ITERATIONS FOR LOOP 2

** COMPOUND RECIRCULATION LOOP:
205120552046

LOOP CANCELED

** COMPOUND RECIRCULATION LOOP:
172517241712

LOOP CANCELED

** COMPOUND RECIRCULATION LOOP:
172517241712

LOOP CANCELED

** COMPOUND RECIRCULATION LOOP:
172517241712

LOOP CANCELED

** COMPOUND RECIRCULATION LOOP:
172517241712

LOOP CANCELED

** SIMPLE RECIRCULATION LOOP:
201520162014
NO. OF ITERATIONS FOR LOOP 3

** COMPOUND RECIRCULATION LOOP:
205520462051

LOOP CANCELED

** SIMPLE RECIRCULATION LOOP:
172417121725
NO. OF ITERATIONS FOR LOOP 15

** COMPOUND RECIRCULATION LOOP:
175617521751

LOOP CANCELED

** COMPOUND RECIRCULATION LOOP:
175217511756

LOOP CANCELED

** SIMPLE RECIRCULATION LOOP:
206120582054
NO. OF ITERATIONS FOR LOOP 3

** COMPOUND RECIRCULATION LOOP:
205120552046

LOOP CANCELED

** SIMPLE RECIRCULATION LOOP:
175117561752
NO. OF ITERATIONS FOR LOOP 11

** SIMPLE RECIRCULATION LOOP:
177117731768
NO. OF ITERATIONS FOR LOOP 21

** COMPOUND RECIRCULATION LOOP:

205520462051

LOOP CANCELED

** COMPOUND RECIRCULATION LOOP:
205120552046

LOOP CANCELED

** COMPOUND RECIRCULATION LOOP:
205120552046

LOOP CANCELED

** COMPOUND RECIRCULATION LOOP:
205520462051
NO. OF ITERATIONS FOR LOOP 10

1

INITIAL NODE	FINAL NODE	WORKING LEVEL	RADON CONC. (BQ/M3)	BRANCH TRAVEL TIME(min)	EQUILIBRIUM RATIO	RADIOACTIVE AGE(min)
1	2	0.0000	0.18	0.006	0.015	0.003
2	2202	0.0000	13.43	0.438	0.596	0.209
2202	2211	0.0000	15.84	0.067	0.661	0.236
2202	1702	0.0001	36.64	0.766	1.435	0.583
2211	2223	0.0005	57.97	0.495	3.305	1.546
2223	2225	0.0007	73.56	0.397	3.285	1.535
2225	2226	0.0007	73.56	0.039	3.357	1.574
2226	2227	0.0021	399.66	1.019	1.965	0.842
2227	2229	0.0055	777.38	1.019	2.598	1.167
2203	1703	0.0265	1881.60	2.717	5.214	2.632
2229	2203	0.0074	938.53	0.435	2.925	1.340
2229	2231	0.0074	937.83	0.433	2.924	1.339
2204	1704	0.0820	3508.68	3.247	8.650	4.754
2231	2204	0.0391	2381.90	3.896	6.081	3.150
2231	2235	0.0119	1238.19	0.810	3.569	1.691
1705	2205	0.2514	4125.62	4.167	22.550	14.559
2205	2235	0.2779	4730.02	1.597	21.735	13.946
2235	2236	0.0608	2596.91	2.712	8.661	4.762
1755	2242	0.2841	4976.77	2.016	21.118	13.485
2242	2236	0.2941	5198.69	0.538	20.934	13.348
2236	2238	0.1019	3168.17	0.396	11.903	6.903
1766	2244	0.1945	4797.38	2.016	15.000	9.043
2244	2238	0.2318	5584.42	1.815	15.356	9.295
2238	2240	0.1228	3598.05	0.244	12.628	7.396
1767	2246	0.2158	4842.49	1.923	16.487	10.099
2246	2240	0.2223	4992.63	0.346	16.473	10.089
2240	2245	0.1475	4124.92	0.780	13.227	7.808

2245	2249	0.1559	4147.84	0.521	13.905	8.277
2225	2243	0.0017	141.58	1.834	4.336	2.122
2243	2247	0.0019	152.65	0.299	4.533	2.235
2247	2249	0.1154	1497.32	35.400	28.526	19.160
2247	2279	0.0019	152.65	0.078	4.669	2.314
2249	2281	0.1869	4197.65	1.967	16.478	10.092
1707	2207	0.2144	4464.21	0.475	17.768	11.022
2207	2281	0.2155	4467.10	0.070	17.852	11.082
2281	2279	0.2062	4358.87	0.177	17.504	10.831
2279	79	0.1720	4186.86	0.259	15.200	9.184
2243	2254	0.0023	226.20	0.670	3.759	1.796
2254	2252	0.0025	285.56	0.160	3.256	1.519
2252	2031	0.0047	616.02	0.890	2.835	1.292
2031	2033	0.0057	720.63	0.270	2.910	1.332
2031	2044	0.0051	616.02	0.108	3.037	1.400
2033	2032	0.0122	1530.45	1.069	2.957	1.357
2033	2037	0.0063	720.63	0.164	3.214	1.496
2032	2036	0.1275	6403.07	4.029	7.367	3.941
2040	2032	0.0313	6406.06	0.272	1.806	0.763
2032	2056	0.0275	4501.37	0.164	2.263	0.993
2032	2034	0.0262	4526.79	0.109	2.144	0.932
2037	2036	0.0175	4616.74	0.652	1.402	0.568
2036	2039	0.0394	4975.04	0.008	2.929	1.342
2036	2256	0.1391	6303.69	3.846	8.163	4.443
2044	2040	0.0216	6199.80	0.740	1.287	0.514
2040	2042	0.0219	6207.70	0.010	1.308	0.523
2039	1706	0.0607	5269.15	0.847	4.264	2.081
2042	1709	0.0442	6432.33	0.647	2.544	1.138
2034	1708	0.0378	3881.12	0.656	3.600	1.708
2223	2224	0.0006	68.78	0.185	3.114	1.442
2224	2004	0.0009	231.44	0.348	1.463	0.596
2004	2006	0.0014	359.02	0.294	1.482	0.606
2006	1719	0.0044	699.26	0.980	2.322	1.023
2004	2010	0.0009	231.44	0.018	1.501	0.615
2010	2008	0.0018	1173.33	0.164	0.572	0.199
2004	2008	0.0024	538.84	0.657	1.675	0.699
2004	2024	0.0041	231.44	2.823	6.522	3.419
2024	2018	0.1256	5351.13	9.167	8.682	4.775
2018	2020	0.0990	2485.94	0.113	14.734	8.857
2020	1718	0.1112	2878.08	1.130	14.289	8.545
2008	2012	0.0031	1138.42	0.174	1.017	0.390
2012	2014	0.0121	1734.46	1.118	2.587	1.161
2014	2016	23.3094	*****	210.000	75.616	77.652
2016	2015	25.6140	*****	16.100	83.092	93.752
2014	2018	0.0961	2236.39	0.324	15.904	9.683
2018	2262	0.1000	2500.72	0.216	14.794	8.899
2012	2261	0.0040	1180.87	0.122	1.245	0.494
2012	2026	0.0082	1459.45	0.686	2.087	0.903
2026	2029	8.2106	*****	100.000	55.269	41.507
2030	2026	9.0066	*****	7.667	60.629	49.939
2026	2028	0.0381	1655.52	0.043	8.522	4.672
2028	1721	0.0432	1884.59	0.660	8.487	4.650
2261	2258	0.0186	2130.70	1.631	3.237	1.508
2258	2208	0.0201	2210.91	0.138	3.370	1.581
2208	2034	0.0238	2325.64	0.331	3.793	1.815

2258	2256	0.0204	2224.93	0.162	3.394	1.594
2256	2255	0.0441	3176.56	1.218	5.131	2.583
2262	2260	0.1806	5307.60	4.820	12.590	7.370
2209	2260	0.0470	6574.83	0.490	2.647	1.192
2042	2209	0.0302	6289.36	0.235	1.779	0.749
2260	2255	0.1494	6611.64	1.197	8.360	4.569
2255	2253	0.0980	4933.10	0.012	7.347	3.929
2206	2253	0.0432	5033.48	0.022	3.178	1.477
2039	2206	0.0427	5020.71	0.132	3.146	1.459
2253	2286	0.0903	5261.68	0.503	6.350	3.314
2286	2287	0.0908	5274.80	0.023	6.371	3.326
2287	2056	0.0940	5321.69	0.135	6.536	3.427
2056	1770	0.1472	6095.88	2.817	8.935	4.938
2254	2285	0.0028	355.91	0.339	2.947	1.352
2285	2060	0.0037	504.14	0.387	2.741	1.242
2060	2048	0.0038	504.14	0.035	2.807	1.277
2060	2046	0.0090	1007.40	1.315	3.319	1.553
2048	2046	0.0086	3005.52	0.402	1.063	0.411
2046	2059	0.1129	4002.96	0.043	10.436	5.920
2051	2046	0.3210	7031.14	0.416	16.891	10.389
2046	2055	0.1128	4002.96	0.036	10.425	5.913
2055	2051	0.1201	5923.92	0.309	7.504	4.027
2059	2062	0.1138	4392.63	0.051	9.589	5.363
2062	2051	1.8561	*****	31.786	28.558	19.184
2062	2064	0.1140	4399.04	0.010	9.591	5.364
1774	2064	0.8785	*****	15.385	28.259	18.951
2054	2051	0.9177	9440.02	0.564	35.970	25.119
2054	2046	0.9340	9091.06	1.133	38.014	26.794
2051	2291	0.3123	6844.51	0.090	16.884	10.383
2056	2054	0.0781	5133.62	0.025	5.629	2.878
2054	2058	*****	*****	155.750	67.952	62.720
2058	2061	*****	*****	0.767	68.366	63.486
2286	2291	0.0956	5392.29	0.224	6.562	3.443
2291	2288	0.2181	6221.78	0.161	12.973	7.633
2289	2288	0.1310	4615.10	0.114	10.504	5.965
2064	2289	0.1289	4549.49	0.068	10.485	5.953
2288	2290	0.1903	5712.97	0.063	12.327	7.191
2291	2290	0.2467	6142.12	1.361	14.860	8.945
1780	2291	0.3275	6240.13	3.827	19.418	12.226
2290	2275	0.1956	5778.58	0.123	12.522	7.324
2275	2279	0.2006	5786.95	0.220	12.825	7.532
1711	2201	0.0010	108.25	1.964	3.315	1.551
2201	2211	0.0032	215.39	2.835	5.546	2.829
2201	2212	0.0028	194.05	2.529	5.434	2.762
2212	2210	0.0046	251.24	1.686	6.748	3.557
2650	2655	0.0047	259.93	0.046	6.670	3.509
2210	2650	0.0046	255.59	0.046	6.707	3.532
2210	2655	0.0046	251.85	0.018	6.760	3.565
2655	21	0.0070	312.77	1.891	8.253	4.501
1702	1710	0.0002	39.38	0.059	1.458	0.594
1710	1711	0.0002	40.10	0.020	1.473	0.602
1710	1722	0.0002	39.38	0.003	1.464	0.597
1722	1711	0.0002	43.70	0.104	1.532	0.629
1722	1724	0.0188	586.13	13.221	11.883	6.889
1724	1725	0.0631	1530.71	0.007	15.243	9.215

1712	1724	0.0743	1771.49	0.031	15.516	9.408
1725	1712	0.0741	1771.19	0.173	15.487	9.387
1713	1725	0.1097	2627.87	2.038	15.448	9.360
1718	1713	0.1170	2979.16	0.508	14.527	8.712
1715	1713	0.0395	1752.22	5.253	8.348	4.561
1719	1715	0.0077	860.04	0.809	3.299	1.542
1715	1716	0.0290	1507.12	3.810	7.117	3.786
1721	1716	0.0473	1973.72	0.491	8.861	4.890
1716	1758	0.0559	2189.09	1.532	9.448	5.271
1708	1758	0.0471	3978.88	0.492	4.377	2.146
1712	1714	0.0809	1812.20	0.992	16.522	10.124
1714	1720	0.0815	1812.20	0.086	16.641	10.210
1714	1717	0.0867	1846.67	0.833	17.368	10.732
1720	1717	0.1282	2125.84	6.330	22.318	14.384
1720	1723	0.1121	1975.22	4.313	20.997	13.395
1717	1723	0.1389	2173.59	2.339	23.650	15.392
1723	1732	0.1352	2120.07	1.808	23.590	15.346
1703	1732	0.0786	2183.20	6.087	13.324	7.875
1732	1735	0.1315	2158.87	0.694	22.538	14.550
1735	1738	0.1316	2158.87	0.015	22.556	14.564
1735	1741	0.1353	2177.16	0.484	22.988	14.890
1704	1738	0.1200	3629.09	2.597	12.237	7.130
1738	1741	0.1337	2367.95	0.424	20.898	13.321
1741	1744	0.1435	2390.55	1.122	22.214	14.306
1744	1747	0.1439	2390.55	0.043	22.270	14.348
1744	1750	0.1442	2393.48	0.078	22.288	14.362
1747	1705	0.1970	2679.58	5.833	27.204	18.126
1747	1750	0.1551	2454.00	1.280	23.379	15.186
1750	1751	0.1771	2534.09	3.294	25.856	17.082
1756	1751	0.1519	4010.45	0.046	14.018	8.356
1751	1752	0.1634	3341.23	0.006	18.095	11.259
1752	1756	0.1513	4009.24	0.120	13.960	8.315
1757	1752	0.0987	6333.61	0.831	5.766	2.960
1709	1757	0.0578	6516.41	0.413	3.280	1.532
1758	1757	0.1751	4267.42	8.221	15.184	9.173
1756	1754	0.1643	4039.86	0.839	15.050	9.079
1754	1755	0.2490	4277.08	5.444	21.542	13.802
1754	1762	0.1852	4089.14	1.351	16.762	10.296
1758	1759	0.0703	3171.79	1.360	8.206	4.471
1706	1759	0.0726	5363.91	0.477	5.009	2.512
1759	1762	0.0944	3970.93	1.409	8.797	4.849
1762	1763	0.1396	4032.06	0.097	12.806	7.518
1763	1766	0.1588	4097.68	1.210	14.340	8.581
1763	1764	0.1414	4037.38	0.118	12.960	7.624
1764	1767	0.1819	4175.09	2.538	16.118	9.836
1764	1765	0.1543	4074.05	0.813	14.016	8.355
1765	1785	0.1606	4091.81	0.394	14.518	8.705
1785	1786	0.1900	4175.87	1.864	16.838	10.350
1765	1769	0.1939	4176.98	2.505	17.178	10.595
1770	1769	0.2079	6557.83	2.324	11.733	6.788
1769	1768	0.2081	4541.02	0.754	16.955	10.435
1768	1773	0.2098	4558.00	0.002	17.027	10.486
1771	1768	0.2105	4565.38	0.015	17.056	10.508
1773	1774	0.3738	6163.52	8.077	22.441	14.477
1773	1771	0.2102	4563.17	0.030	17.045	10.500

1768	1783	0.2102	4558.00	0.029	17.066	10.514
1771	1783	0.2277	4731.73	0.992	17.802	11.046
1783	1780	0.2455	4912.14	1.607	18.488	11.545
1783	1786	0.2265	4765.37	0.567	17.589	10.892
1786	1707	0.2065	4436.95	0.021	17.217	10.623
2015	2014	27.7280	*****	16.100	89.949	109.852
2029	2030	8.2859	*****	0.767	55.777	42.272
2061	2054	*****	*****	16.100	76.552	79.586